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CORRELATION OF THE TERTIARY FORMATIONS OF THE PHILIPPINES WITH THOSE OF EUROPE, ASIA, AND AMERICA

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It will be remembered that one of the results of the First Pan-Pacific Scientific Conference, held at Honolulu in 1920, was the formulation of the basis of correlation of the post-Cretaceous formations of the Pacific region. It was formulated that—[1]

> As the margins of the Pacific and the islands within its confines are remote from Europe, direct tracing is out of the question, but two possibilities are present. One is to correlate with Asia and work westward across it to Europe; the other is to correlate with America and through it to correlate with Europe.

The purpose of the present paper is to present a tentative correlation of the older Tertiary formations of the Philippines with standards already established in Europe, Asia, and America—not so much to establish definitely the assignment of these horizons to subdivisions of the Tertiary as to call attention to the fact that the previous assignment of the Batan, the Binañgonan, and the Vigo formations to Miocene is not supported by palæontological evidence. In this attempt at tenta-

[1] Vaughan, T. W., The basis of the correlation of post-Cretaceous formations of the Pacific region, Proc. First Pan-Pacific Scientific Conference, Honolulu (1921) 867.

tive correlation several things are borne in mind; namely,[2] (1) "in similar Neogene sediments of Europe and the Indies the deposits in the latter region must contain a higher percentage of living species than the former;" (2) tracing from Europe to southeastern Asia is possible only for early Eocene; and (3) the presence of similar organisms in post-Eocene formations of the East Indies and Europe is due to migration across Central America from the Atlantic to the Pacific, or vice-versa, during middle and later Eocene time, middle and later Oligocene time, and oldest Miocene time.

In the Philippines the lowest horizon of the Tertiary, the Eocene, is recognized, although it must be said that beds of Eocene age are known only at very few localities. At least a portion of the Philippines was land mass during Eocene time, but the fossil terrestrial fauna and flora are at present very imperfectly known.

The best known and the most widespread of the older Tertiary formations of the Philippines is a series consisting of shales and grit with coal, shales and sandstones with oil seeps, and limestones with large-sized *Lepidocyclina*. Three quite distinct formations make up this series; namely, the Batan, the Binañgonan, and the Vigo. The Batan formation, first named by Smith[3] in 1913, consists of alternating gray shales, grits, sandstone, and coal seams, and has a thickness in some places of several hundred meters. The Binañgonan formation is yellow to white or bluish gray limestone, massive or heavily bedded, containing large-sized Foraminifera, the forms measuring 2 centimeters or more in diameter. This formation was also first named by Smith[4] although in a later publication[5] he changed the name to Cebu limestone. The Vigo formation consists of alternating beds of bluish gray, gray, or black shales and yellow and brown sandstones, sometimes massive or imperfectly bedded. According to Dickerson,[6] the limestone containing the large-sized *Lepidocyclina* is equivalent to the shales and sandstones of the Vigo formation and "the limestones, shales, sand-

[2] Martin, K., The age of the Tertiary sediments of Java, Proc. First Pan-Pacific Scientific Conference, Honolulu (1921) 763.

[3] Philip. Journ. Sci. § A 8 (1913) 242.

[4] Loc. cit.

[5] Geology and Mineral Resources of the Philippine Islands, Bur. Sci. Pub. 19 (1924) 78.

[6] Philip. Journ. Sci. 20 (1922) 209.

stones, and coal are different depositional facies within the same group."

The stratigraphy of the coal-bearing formation has been the subject of investigation by a number of workers. Becker and Abella, among others, regarded it as Eocene, while Smith and Dickerson assigned it to the Miocene. On the basis of Foraminifera, Douvillé referred the lignitic horizon to the Oligocene. In places, notably in Cebu, the Vigo shales lie above the coal measures. In other places the Binañgonan limestone lies in patches over the coal measures.

The foraminiferal fauna of the Binañgonan limestone has also been the subject of a number of investigations. The findings of Douvillé [7] and of Yabe [8] give the genus *Lepidocyclina* as the most characteristic fossil. Douvillé correlates the middle limestone with large *Lepidocyclina* with the Aquitanian, and the lignitic horizon and lower limestone with the Stampian, which represents Oligocene. Douvillé's determinations were based on a sample of bluish gray limestone (upon which the foraminifers stood out in black) from Batan Island, one of the Philippine coal fields. He found it to contain *Nummulites subniasi* and a curious *Lepidocyclina* belonging in the section of *Nephrolepidina, L. smithi.* The coexistence of *Nummulites* and *Lepidocyclina* is regarded by him as characteristic of the Stampian, Oligocene. This limestone is a part of the lignitic horizon and is found intercalated between beds of lignite. The following table summarizes the conclusions of Douvillé:

Philippines.			Borneo.	
II.	Upper limestones with small lepidocyclinas	*Lepidocyclina verbeeki*	H. Burdigalian.	
		Miogypsina		
		Cycloclypeus communis		
	Middle limestone	*Cycloclypeus communis*	G.	Aquitanian.
		Operculina complanata		
	Lower limestones with large lepidocyclinas	*Lepidocyclina insulaenatalis*	F.	
		Lepidocyclina richthofeni	E.	
		Lepidocyclina formosa		
I.	Lignitic horizon and lower limestones with nummulites	*Nummulites subniasi*	D. Stampian.	
		Amphistegina niasi		
		Lepidocyclina smithi		

[7] Les foraminifers dans le Tertiaire des Philippines, Philip. Journ. Sci. § D 6 (1911) 53–80, 4 pls.

[8] Notes on a Lepidocyclina limestone from Abu, Science Reports, Tohoku Imp. Univ. 5 (1919).

The work of Cushman [9] in the American Caribbean region on fossil Foraminifera gives the range of the genus *Lepidocyclina* as upper Eocene to Oligocene. Vrendenburg's [10] studies on the distribution of the genus *Lepidocyclina* in the nummulitic series of India showed that *Lepidocyclina* occurs from the very base of the Oligocene as far as the series are developed. Yabe,[11] analyzing the results of Rutten's studies of foraminiferal rocks from southern and eastern parts of Borneo, says in part:

> Thus the oldest Miocene and Oligocene deposits, according to Rutten, are characterized by Lepidocyclinas of larger and smaller sizes, while the smaller ones alone are found together with *Miogypsina* in all parts of Miocene deposits except the lowest division.

It is thus seen that, while in the American Caribbean region *Lepidocyclina* is characteristic of upper Eocene and Oligocene, in India and in the islands of the East Indies it starts from the base of the Oligocene and ranges through the Miocene. The presence of *Lepidocyclina* in foraminiferal rocks in the Philippines can then be regarded as indicating at least Oligocene age.

Mr. Dale D. Sparks, at present palæontologist for Cia. Emmex de Petroleo y Gas, South America, while working on orbitoid Foraminifera at Leland Stanford Junior University, California, examined sections of Philippine *Lepidocyclina* limestone from Montalban Gorge, near Manila, Rizal Province, and identified, besides the species recognized by Douvillé and by Yabe, *Lepidocyclina canellei* Lemoine and R. Douvillé. This species is identified by comparison with the figures and descriptions of Cushman.[12]

Lepidocyclina canellei Lemoine and R. Douvillé has been collected from the Antigua formation (Oligocene) of the Island of Antigua in the West Indies, from the Culebra formation (Oligocene) of the Canal Zone (both type localities of subdivisions of the Tertiary system in the West Indies and Central America), and from the Oligocene of Trinidad.

The most characteristic molluscan fossil of the coal measures is *Vicarya callosa* Jenkins. This species has never been found in beds overlying the series, and is moderately common through-

[9] The American species of Orthophragmina and Lepidocyclina, Prof. Paper 125-D, U. S. Geol. Surv. (1920).

[10] Rec. Geol. Surv. of India 35 [1] (1907) 63.

[11] Notes on a Carpenteria limestone from British North Borneo, Science Reports, Tohoku Imp. Univ. II 5 [2] (1919) 1.

[12] The American species of Orthophragmina and Lepidocyclina, Prof. Paper 125-D, U. S. Geol. Surv. (1920).

out the Philippines. It was first reported by Martin,[13] and has been considered by him and others as a good guide to the tropical Miocene. It will be noted that there are only two species of *Vicarya;* one is *V. verneuili* d'Arch. and the other is *V. callosa* Jenkins. Martin [14] noted that it will be difficult to separate the two species as long as *V. verneuili* is represented by such poor material, and he expresses the opinion that probably the two forms belong to one very variable species. Regarding the range of the genus, Martin [15] has the following to say:

> For *V. callosa* Jenk. has hitherto been found only in the upper Miocene of Java, and *V. verneuili* d'Arch. occurs only in the Gaj series of western India, which also belongs to the Miocene.

In this connection it is interesting to note the conclusions of Vrendenburg [16] in his analysis of the Singu fauna, in which he expresses the opinion that the Singu beds are Oligocene. *Vicarya verneuili* occurs in bed P at the upper limit of the older subdivision, which is characterized by the typically Oligocene fossil *Turritella magnasperula.*

Another molluscan criterion for referring the lignitic horizon to Oligocene is provided by the finding by Smith [17] in the lower limestone on Batan Island of *Ampullinopsis.* Dr. W. H. Dall, of the Smithsonian Institution, is authority for the statement that the presence of *Ampullinopsis* is an indication of Oligocene age. Regarding the Batan beds, the following statement by Reinhott [18] is of particular interest:

> The sedimentary series belong unquestionably to the Tertiary period. Professor Mayer of Zurich and Doctor Dall of our Smithsonian Institute agree, from the examination of fossils collected and personally submitted by me, that the upper limestone should be referred to the Oligocene epoch.

It has been claimed by Dickerson [19] that 75 per cent of the specifically determined forms from the Vigo are referable to living species. It is difficult to subscribe to this assertion, because Dickerson presented only a list of species the determination of which cannot be checked and, judging from the few

[13] Sammlungen des geologischen Reichsmuseums, Leiden 5 (1896) 53–69.

[14] Sammlungen des geologischen Reichsmuseums Leiden, Heft III Neue Folge, 2 (April, 1917).

[15] Loc. cit.

[16] Rec. Geol. Surv. of India 53 [4] (1921).

[17] Contributions to the stratigraphy and fossil invertebrate fauna of the Philippine Islands, Philip. Journ. Sci. § A 8 (1913) 240.

[18] Eng. Mag. (1906) 30, 510.

[19] Review of Philippine paleontology, Philip. Journ. Sci. 20 (1922) 203.

figures he presented, several of his determinations are not precise. It is admitted that a large percentage of the fossils present in the Vigo formation are still living in Philippine waters, but it is seriously questioned whether the percentage is as high as 75 per cent.

There is wide disagreement between Doctor Dickerson and myself as regards systematic classification. Doctor Dickerson's specimens are not in the Bureau of Science palæontological collection; they were collected while he was chief geologist for the Richmond Petroleum Company and were taken away upon completion of its work in the Philippines. I am hoping that some colleague will have a chance to reëxamine the material in order that the percentage of species common to the beds may be compared with some accuracy. My identifications of his species were made by examination of the figures he presented. The plates discussed below, which accompany his paper just cited [19] will serve to illustrate wherein we differ:

Plate 2, fig. 22, *Epitonium* sp. This is not an *Epitonium*, as it has no ribs and the aperture is not round. It is probably a *Pyramidella*.

Plate 3, figs. 14*a*, 14*b*, *Nassa crenulata* Bruguiere. *Nassa crenulata* Bruguiere is the same as *Nassa arcularia* Linné and has a flaring lip. The shell figured is probably *Nassa crenata* Hinds or its variety *margaritifera* Dunker.

Plate 4, fig. 9, *Oliva* cf. *utriculus* Gmelin. *Oliva utriculus* Gmelin is the same as *Oliva gibbosa* Born and has a callous columella. The shell figured looks more like *Oliva acuminata* Lamarck or *Oliva nebulosa* Lamarck.

Plate 7, fig. 4, *Spisula* sp. This is not a *Spisula*, as this genus has concentric ribbing only, never cross-hatching or basket work, as shown in the figure.

Plate 12, figs. 6*a*, 6*b*, *Flabellum* cf. *australe* Moseley. This is very different from *Flabellum australe*, which is a large, dense, heavy shell, with no pronounced costal markings.

Plate 12, fig. 7, *Leptoria* sp. This is probably a species of *Maeandra*. *Leptoria* has long valleys and a lamellar columella.

Plate 13, figs. 3*a*, 3*b*, *Clypeaster* sp. This is not a *Clypeaster;* it is a *Peronella*.

It would seem there is sufficient ground for questioning the correctness of Dickerson's determinations and, until more reliable work has been done on the determination of the fossil species, the percentage of the living species in the Vigo beds cannot be estimated.

In addition to the foregoing palæontologic evidence, the following notes by Dr. Bailey Willis, of Leland Stanford Junior University, who spent about two months in the Philippines and

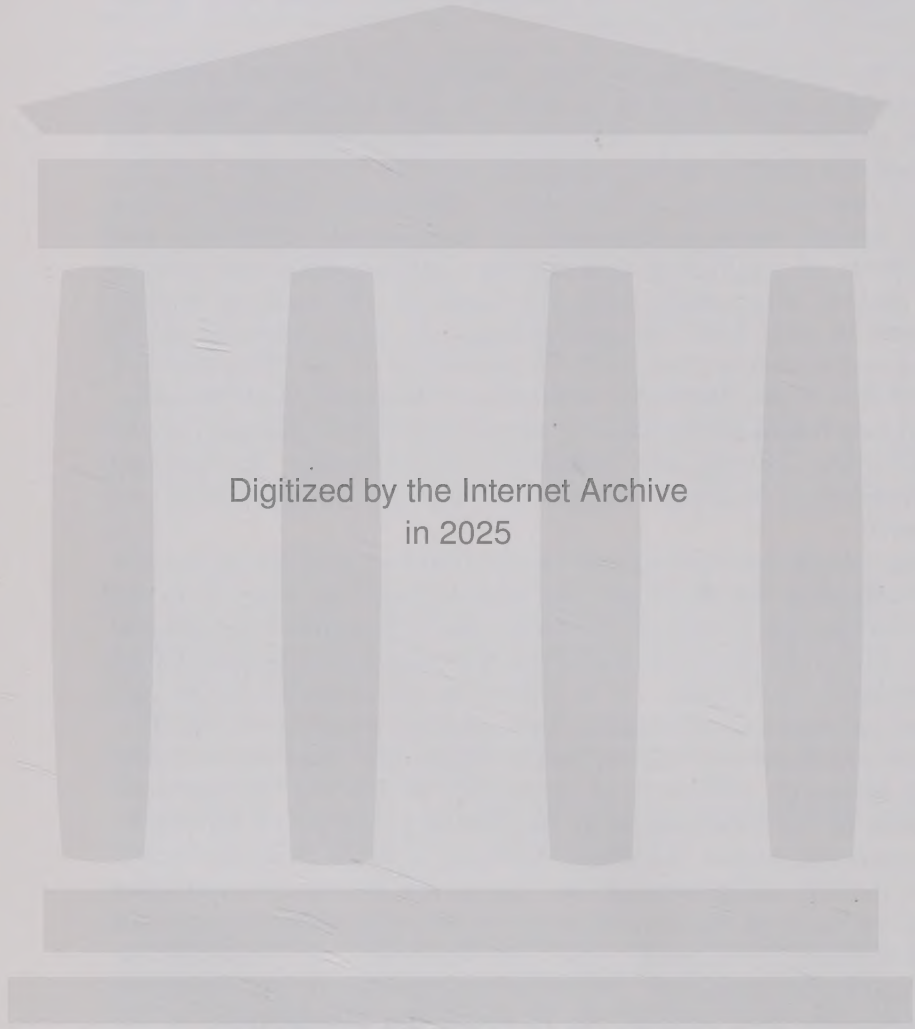
visited Luzon, Cebu, and Mindanao, are of great interest, as they represent the physiographic side of the matter. Doctor Willis says:

> Judging by the physiographic maturity of the plateau of northern Luzon and the Diuata range of Mindanao, the uplifts have been exposed to subaerial erosion since early Miocene time. If this be so the limestone [*Binañgonan*][20] involved in the structure of these masses must be pre-Miocene and probably Oligocene.

The correlation of the later Miocene and younger deposits must in a large measure be made by interpolation, based upon the degree of faunal similarity or dissimilarity between the Oligocene faunas on the one hand and the Pleistocene and Recent marine faunas on the other. Thorough familiarity with the Recent fauna is thus seen to be absolutely necessary, and students of Philippine stratigraphy, palæontology, and geologic history must begin with the study of the existing marine fauna in and about the Archipelago. In this connection attention is directed to Cushman's Foraminifera of the Philippine and Adjacent Seas, Bartsch's studies on Philippine land Mollusca, and two recent publications of mine, Recent Madreporaria of the Philippine Islands and Summary of Philippine Marine and Fresh-water Mollusks, as aids to Philippine palæontologic research.

In conclusion, while I am of the opinion that the Batan, the Binañgonan, and the Vigo formations should be referred to the Oligocene age, it should be stated that Philippine stratigraphy must be worked out in detail first and assignment to established standards made later. It is desired to call attention to the fact that reference of Philippine formations to divisions of the Tertiary are based on fragmentary evidence and must not be taken too seriously. While it is convenient to use the international names of the subdivisions of the Tertiary, the use of Philippine formational names to indicate horizons is much to be preferred. The definite assignment of the Vigo to the Miocene is premature and, as has been shown, not in accordance with palæontologic and physiographic evidence. The use, therefore, of Vigo-Miocene should be discontinued. When the stratigraphy of the Philippine Islands has been worked out in detail and the sequence of the different strata is known with more or less definiteness, then assignment of the different formations to subdivisions of the Tertiary will be in order.

[20] Italics are mine.—L. A. F.



NOTE ON LOCAL TERMINOLOGY OF CERTAIN MANIFESTATIONS OF YAWS

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Considerable misunderstanding and confusion have arisen from the use in the literature of local popular names in the designation of the clinical manifestations of yaws. The polyglot nature of the literature concerning yaws has further contributed to this confusion. Unfortunately, the practice of using local colloquial terms becomes almost indispensable after long residence in any particular tropical country. Throughout what may be styled the Latin Tropics, the popular Spanish nomenclature of yaws manifestations is generally understood, whatever the names of the same affliction may be in the native dialects. This, however, appears not always to be the case with frambœsiologists who have worked among other than Spanish-speaking people, owing to the similarity of some Spanish words to Latin words and to the fact that, having preserved a great similarity to Latin, these Spanish words have acquired a new shade of meaning. As an instance of such misunderstanding arising from the use of local names we may cite the review of our paper in a recent publication.[1] There the reviewer takes exception to our stament concerning the word "clavos."

For the information of the reader who may not be familiar with the popular medical terminology used in the Latin Tropics, the following explanation is presented.

In the minds of patients and other laymen the word *clavos* (plural of clavo) connotes any form of yaws, *of long duration,* that is located on the palms of the hands or, more frequently, on the soles of the feet and inconveniences the patient in walking or in performing manual work. At least four forms of yaws manifestations may be distinguished. Without diagnostic differentiation, all of them are popularly called "clavos."

[1] Trop. Diseases Bull. 24 (1927) 300, 301.

First, a persistent primary lesion, located most frequently around the ankles, that has developed an ulcerative form and gradually has extended to the dorsoplantar margin of the foot.

Second, a metastatic yaw located on or about the dorsoplantar margin or the sole of the foot.

Third, a typical, persistent late lesion termed "keratodermia" by Castellani and by others, as Gutierrez included it under the term keratosis.

Fourth, psoriasis palmaris or plantaris frambœsica.

The palm lesions described and illustrated in our paper [2] were metastatic, inflammatory, exudative efflorescences. They started as distinct, slightly elevated, reddish macules with subsequent central circular exfoliation of the white, thin epidermis. This exfoliation advanced toward the periphery of the lesion much faster than the spreading of the elevated macule progressed. The defects thus produced appeared reddish and fairly dry. There was no crust formation or oozing. These were early acute, metastatic efflorescences that occurred simultaneously with the cropping out of typical yaws on the other parts of the body. On the palms they occurred in successive crops, and new ones developed while the old ones were fading away. Sometimes they became confluent, producing maplike exfoliated lesions. At other times they would disappear before the exfoliation set in. No keratosis, either of the primary efflorescence or of the skin surrounding the lesions, was observed at first.

Contrary to the belief expressed by H. S. Stanus, we distinguish the lesion on the palms as described in our publication [3] from the commoner lesion called "keratodermia" by Castellani and Chalmers. We consider the lesion we described to be an early, metastatic, evanescent frambœside that appears, first, as a flat, elevated, reddish macule, subsequently undergoing exfoliation. In the lesion termed keratodermia by Castellani and Chalmers the inflammatory reaction is pushed into the background, and the lesion, from the start, appears as a slow, diffuse, and extensive keratosis of the sole. The last-named lesion is a late manifestation of yaws and is persistent.

Any of these four lesions having reached the thick skin of the margin or the pads of the sole will produce its further and painful thickening. They are then promiscuously called "clavos." The

[2] Schöbl, Otto, A. W. Sellards, and G. R. Lacy, Some protean manifestations of the skin lesions of yaws, Philip. Journ. Sci. 30 (1926) 475–481.

[3] Loc. cit.

Spanish word clavos means iron spikes or nails (not finger nails or toe nails). It is not identical with the dermatological term *clavus*. The Spanish name for corn (*clavus*) is *ojo de gallo* (chicken-eye); that of callus is *callos*. Consequently, the term clavos does not exclusively mean such extensive and diffuse thickening of the epidermis of the soles or palms as one finds in keratoderma.

Aside from the last-mentioned condition (keratoderma plantare) we include under the name clavos the metastatic yaw located on the sole of the foot or palm of the hand.

The early and evanescent metastatic frambœside on the palm of the hand, as described in our paper,[4] and the keratosis of the skin surrounding these lesions is a combination of the two processes. In this stage the lesion is indistinguishable from the so-called psoriasis palmaris syphilitica, otherwise syphiloderma manus. Any form of yaws manifestation located on the sole of the foot or on the palm of the hand will sooner or later show more or less pronounced keratosis, but the three forms of generalized yaws above mentioned must be considered as morphologically distinct.

The grounds on which this differentiation is based are the following:

1. MORPHOLOGIC DIFFERENCES OF THE PRIMARY EFFLORESCENCES

One form starts as a macule, which changes into a flat papule with subsequent exfoliation of the epidermis within the area covered by the lesion. Some of these frambœsides disappear before exfoliation sets in, while others are superseded by a diffuse hyperkeratosis of the skin surrounding the frambœsides.

Another type of lesion commences as a metastatic yaw modified by the thickness of the skin of the sole or the palm, as the case may be. Subsequently, the keratotic process surrounding the yaw extends farther over the hitherto unaffected skin.

The third type of lesion is a diffuse hyperkeratosis from the very beginning. Exfoliation of the superficial layers of the excessively thickened epidermis produces either large, maplike, superficial defects with cribrated basis, or the effect known in the literature as "moth-eaten feet." In other instances there develops a lesion described in the literature as keratoderma sulcatum.

[4] Loc. cit.

2. DIFFERENCES IN PATHOGENY

The other reason why the three manifestations of generalized yaws on the palms and soles should be considered as distinct forms is their different pathogeny. The first-mentioned two forms are metastatic lesions; one commencing as a metastatic yaw, the other as an early metastatic frambœside. This pathogeny is suggested by their coincidence with metastatic yaws manifestation on other parts of the body. The third form occurs as often in cases that never have exhibited a so-called "secondary stage" as it does in those that have exhibited that stage.

The correctness of this conclusion, drawn from clinical observation, has been fully confirmed by experimental evidence, which will be published in an early number of the Philippine Journal of Science. While the macular exfoliative process described by us was observed exclusively in experimental animals showing generalized yaws, the third form (keratoderma plantare) was observed to be particularly pronounced in those animals that showed late so-called tertiary lesions (gangosa) without "secondaries."

Taking up the remark of the reviewer [5] as to one of the lesions described by Gutierrez and quoted by us as likely to be identical with our experimental lesion that we designated keratoid frambœside, we disagree with the opinion expressed by him that one of the lesions is "melung." The name "melung" is a local name used by a tribe of Negroes in Africa. The spelling of this word was coined by Ziemann [6] in such a way as to enable a German not an English-speaking person to approximate, phonetically, the pronunciation of the native word. In order to show the grounds on which we claim that the lesion described by us and that previously described by Gutierrez are identical and quite different from "melung" we must refer to the original article of Ziemann for the definition of the lesion. Translating freely, we find it described as a slowly progressing depigmentation of the skin and the hair. It is symmetric, appearing in blotches which become at times confluent, *but always intersected by normal pigmented skin.* The *thickness of the epidermis*

[5] Trop. Diseases Bull. 24 (1927) 300, 301.

[6] Ueber "Melung" (Beta bei den Duala-Negern), eine eigenartige Hautkrankheit der Neger in West-Africa, von Dr. Hans Ziemann, Marineoberstabsarzt und Regierungsarzt, Archiv für Derm. und Syph. 74 (1905) 163.

is reduced. The *surface is very smooth* and *the margins of the depigmented lesions are sharp and show no sign of inflammation. The entire depigmented lesion is not raised* above the level of the surrounding normal skin. It is called by Ziemann "partial vitiligo" or "leucoderma."

It is distributed over the palms and dorsa of the hands and on the soles and dorsa of the feet, but never extends above the distal third of the leg or forearm.

The lesion experimentally produced by us took the form of a crop of macular circinated depigmented lesions that included the hair. It was *raised above the level* of the surrounding skin and consisted of *elevated papules.* The lesion, therefore, was rough on palpation, *its individual papules resembling those of keratosis pilaris.* The margin showed a slightly *inflamed base.* Desquamation was only slightly developed. The *thickened epidermis* was easily scraped off and the base did not bleed. The lesions were located on the *trunk of the body,* the *hands and feet being free from them.*

The lesions described and illustrated by Gutierrez [7] are, as is clearly evident from his photograph, *raised* and depigmented. They are seen to consist in a *"follicular heaping"* and are located on the back and on the forearms and show *"furfuraceous desquamation."* The hands and feet are free from them.

It is evident from this brief comparative description that the only thing in common between the lesions described by us and those previously described by Gutierrez on the one hand, and those described by Ziemann as "melung" on the other, is the depigmentation. The lesions similar to the "melung" of Ziemann are not absent in the Philippines. An illustration of a case is given in Gutierrez's publication,[8] where the vitiligo is combined with keratoderma plantare. It is possible that the "melung" described by Ziemann is nothing but an aftermath of yaws, in as much as it is known that both the hyperpigmentation, but more particularly the depigmentation, of the skin following yaws is very persistent. However, it is quite as possible that at least some of the so-called "melung" cases are lesions of another etiology.

[7] Yaws: Its manifestations and treatment by neosalvarsan, Arch. Derm. and Syphilol. 6 (1922) 265–287, fig. 13.

[8] Keratosis palmaris et plantaris due to Framboesia, Arch. Derm. and Syphilol. 8 (1923) 382–392, fig. 5.

The purpose of the dermatologic descriptions and illustrations in our paper [9] was not to present new or hitherto unknown skin manifestations of yaws. Our sole aim was to give a description of the lesions, not only that those familiar with yaws could recognize them, but also that dermatologists unacquainted with tropical medicine might recognize these lesions, because of their versatility in dermatology. Consequently, in the absence of uniform dermatologic nomenclature, these lesions were likened by us to skin diseases known the world over, including the Tropics. Thus the names lichenoid (lichen planus), keratoid (keratosis pilaris), frambœsiderma manus (syphiloderma manus) were applied.

The main reason for publishing our paper is the fact that "All of the three atypical lesions herein [10] described were observed in experimental cases whereby their etiology was definitely determined."

[9] Schöbl, Otto, A. W. Sellards, and G. R. Lacy, Some protean manifestations of the skin lesions of yaws, Philip. Journ. Sci. 30 (1926) 475–481.

[10] Loc. cit.

NOTE ON BACTERIOLOGICAL DIAGNOSIS OF BACILLARY DYSENTERY

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SEVEN TEXT FIGURES

In a country like the Philippines, where bacillary dysentery is endemic and occurs throughout the year with more or less regularity during a certain season of the year, the clinical diagnosis in the majority of cases offers little difficulty to the practitioner. The sudden onset, rise of temperature, abdominal pain, and occurrence of several cases within a few days in a community leads the physician, provided he has excluded cholera, to the diagnosis of bacillary dysentery. Although the severity of outbreaks and the mortality vary from time to time, bacillary dysentery usually scores heavily among children. It is a generally accepted tradition in dysentery-stricken countries that cases among them caused by the Shiga-Kruse type of *Bacillus dysenteriæ* are more severe and mortality is higher than in those caused by mannite fermenters. This should not, however, be construed to mean that cases caused by mannite fermenters do not need immediate and prompt therapy. A physician should not let himself be misled by the report of the laboratory that the case is a light one if not caused by the Shiga-Kruse type of *B. dysenteriæ*. It is strongly advised, and practice bears this out, that the physician do not await the bacteriological diagnosis but commence serum therapy immediately. An experience in the Philippines of more than ten years in serum therapy of dysenteric cases has shown that the mortality in bacillary dysentery, in adults and children alike, can be reduced to the minimum by prompt application of serum in sufficient quantity but principally by administering the serum as early as possible. An alert physician will insist on examining the stool himself in a case of intestinal disorder and, with little experience, he will be able to discover by the naked eye strips of mucus or strips of mucus and blood in the still fæcal stool

that will lead him, in consideration of other clinical symptoms, to diagnose the case as bacillary dysentery and to take immediate steps by injecting antidysenteric serum and requesting laboratory confirmation of his clinical diagnosis of bacillary dysentery. The findings made by the naked eye of mucus and blood will be further confirmed by microscopic examination. The helpfulness of this method has been repeatedly pointed out.(2) In the great majority of acute cases of dysentery it will be possible to confirm bacteriologically the clinical and microscopic diagnosis of dysentery.

Naturally, the collection of samples and the selection of the portion of the stool to be used for laboratory examination are of utmost importance. This has been demonstrated by Saisawa and Tanabe(7) in their work on healthy dysentery carriers, and also in the work of Vazquez-Colet(9) on dysentery carriers among food handlers in the Philippines. When it is once realized that a case of chronic dysentery exists and is causing intestinal disorders and that the pathologic changes are localized in the end of the large intestine, of either a mucous chronic inflammatory character or an ulcerative chronic type, it will at once become evident that the distribution of the dysentery bacilli throughout the specimen of stool is not so uniform as in cholera, or even in typhoid, and the importance of selecting from the specimen a special portion macroscopically suspicious as the dysenteric inflammatory product will be recognized. Owing to the lack in bacteriological technic of enrichment medium and of standard procedure for isolating *B. dysenteriæ,* one of us suggested years ago(6) the use of Teague's medium for bacteriological diagnosis of dysentery. The Teague's plate is particularly valuable in a search for carriers on a large scale.

The necessity of submitting, for bacteriological diagnosis, specimens in as fresh a condition as possible is evident from the consideration of the action of the bacteriophage that strongly interferes with successful isolation of *B. dysenteriæ* from otherwise typical specimens of stool.

In analyzing the procedure described below for the isolation of *B. dysenteriæ* one can see that the principle of elimination is followed. The first step is to note the shape of the colony and the effect of the growing bacteria upon lactose, methylene blue-eosin being used as indicator; the second step is to examine for motility; the third step, which is combined with the second, is to

note the microscopic agglutination reaction; the final step is to note the behavior of the isolated culture toward carbohydrates other than lactose, principally Russell's medium, mannite, maltose, and saccharose. In arranging the procedure in this way it is possible to give early preliminary information to the interested physician. Within a few hours after the plates had been seeded (eight to ten hours) a preliminary report in certain instances could be given, by fishing out suspicious colonies, under a magnifying lens if necessary, and performing the motility and agglutination tests with serum prepared for the treatment of bacillary dysentery by immunization of horses with strains of a well-known antigenic property. At the same time, in as much as in a case of acute dysentery more than two or three suspicious colonies of the same type are found, as a rule, these are fished out and transplanted into Russell's medium and other carbohydrates. In this way a specimen delivered at the laboratory for examination for *B. dysenteriæ*, for instance, before 9 o'clock in the morning could be reported as suspicious macroscopically and microscopically upon receipt of the specimen and as highly suspicious bacteriologically before 5 o'clock in the afternoon, provided the shape of the colony corresponded to that of *B. dysenteriæ* on Teague's medium and the motility and agglutination tests agreed with a control of known *B. dysenteriæ* culture. Within twenty-four hours—that is, next morning—confirmatory tests of sugar reactions, which would not only indicate the presence of *B. dysenteriæ* but also determine the type, could be made.

Recently it was decided to subject this procedure which has been in vogue for several years in this laboratory to a revision in view of a statement made by G. R. Lacy.(4) Lacy makes the following statement:

> * * * The practical point which we would mention in connection with this report is that, had we depended upon the immune serum of typical Shiga alone for diagnosis of these organisms, we should have missed eighteen out of the forty-five and, even with the sera of the two fixed groups, we should still have missed nine of the forty-five, or practically 20 per cent. We feel, therefore, that the use of cultural, biological, and serological methods should always be employed in studying this group of organisms.

It is obvious that tests other than mere serologic must be used for classification of pathogenic bacteria. The study of Lacy on

serologic differences of grouping brings out this point very clearly. We must, however, emphasize the differences between the serum as prepared by Lacy for his study and the serum as prepared by us for therapeutic purposes and, incidentally, used for diagnostic purposes in the laboratory. The first difference is that, while Lacy used small laboratory animals, rabbits, our serum is derived from immunized horses. The second difference is that, while Lacy used a high dilution in order to bring out the differences, we are using for diagnostic work a low dilution in order to avoid these differences in dysentery strains. Furthermore, the serum prepared by us is so polyvalent with regard to Shiga strains that it affects all known strains of *B. dysenteriæ* investigated, including those found by Lacy to belong to three different groups.(8) The fact that Lacy found our serum to protect laboratory animals against subsequent infection with strains, no matter to which serologic group of his classification(4) they belong, is an indication of the polyvalency of our horse serum. The explanation lies mainly in the findings on antigenic properties of various strains of *B. dysenteriæ* as a basis for serologic grouping (8) and in the use of a different donor of immune serum.

There is a further difference between the material experimented on by Lacy and the material we used. While we used specimens from patients, carriers, or autopsies, Lacy examined the series of forty-five strains designated as *B. dysenteriæ* by laboratories in various countries. In other words, the majority of his cultures were stock cultures, not freshly isolated strains.

The serologic differences particularly evident in absorption experiments of artificially reproduced mutants have been sufficiently brought out by Morishima.(5) Therefore, the conclusion drawn by Lacy from his experiment does not directly apply to the identification of strains isolated from specimens, particularly in acute cases, when horse serum prepared by immunization against strains of permanently good antigenic property is used.

TECHNIC

Selection of material for examination.—The specimen submitted for examination was placed on a sterile Petri dish. With the tip of a sterile platinum loop a portion of the material containing mucus was picked up and washed in a tube of distilled water. This washed portion constituted the material for inoculation on the lactose methylene blue-eosin agar plates.

The samples were plated on lactose methylene blue-eosin agar by spreading the washed fæcal material over the plates. The plates were incubated overnight (37° C.). The next day suspicious colonies were marked. These colonies were somewhat transparent, of a pinkish color, and had irregular edges. From these colonies motility test and agglutination test with undiluted and diluted (1 : 50) antidysenteric or typhoid and paratyphoid serum were made. A modification of Barber's isolating chamber(1) was used for this purpose. This chamber is prepared by fastening strips of glass to a slide with Canada balsam, as shown in fig. 1. The chamber used by us was 7 centimeters long, 4 centimeters wide, and 0.75 centimeter high. To examine the suspicious colonies for motility the following procedure was observed. A cover glass large enough to cover the chamber completely was prepared as suggested by Barber; that is, a little vaseline was carefully smeared on the slide, after which the cover glass was thoroughly polished. This was done to prevent the drops from running together. Then drops of salt solution were placed on the cover glass by means of a platinum loop. With a straight platinum wire, a bit of each suspicious colony was picked up and emulsified in two drops of salt solution, so that there were two drops of bacterial emulsion for each colony, arranged as seen in fig. 2.

The cover glass was then turned over and rested on the chamber, the drops downward, as in fig. 3.

The drops were examined under the microscope for motility and the result was recorded. Then the agglutination tests were made. Nonmotile bacilli were tested out with antidysenteric serum, while motile bacilli were tested with typhoid and paratyphoid A serum. The procedure was as follows: On the side of the first drop of bacterial emulsion a drop of pure antidysenteric serum or antityphoid serum, as the case may be, was placed. On the side of the second drop of bacterial emulsion, a drop of a 1 : 50 dilution of serum was placed (see fig. 4). Then, with a platinum wire, the drops were joined as indicated in fig. 5.

The cover glass was put in a wet chamber, the drops upward. This consisted of a Petri dish, on the bottom of which a piece of wet filter paper was placed to prevent drying up of the drops on the slide, and two pieces of glass tubing on which the cover glass rested (fig. 6). The glass tubing was filled with water, thus supplying the moisture necessary to keep the filter paper wet.

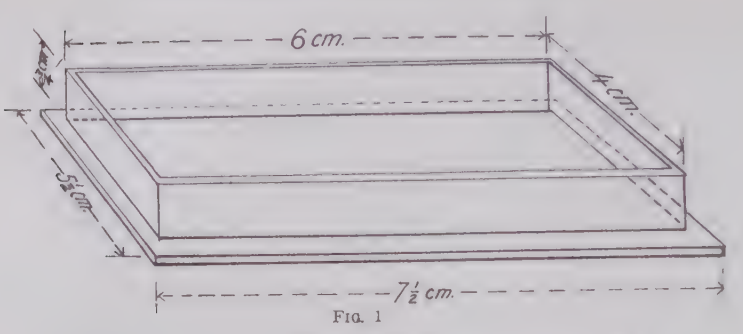

FIG. 1

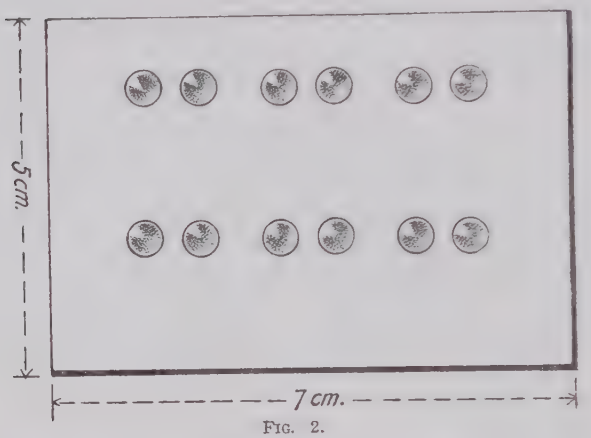

FIG. 2.

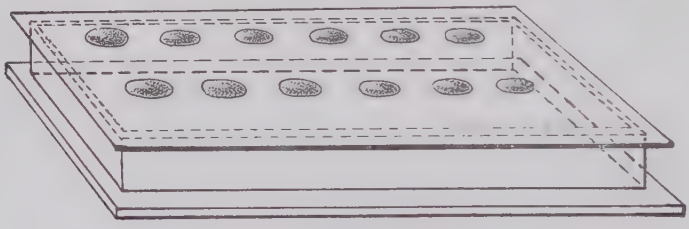

FIG. 3.

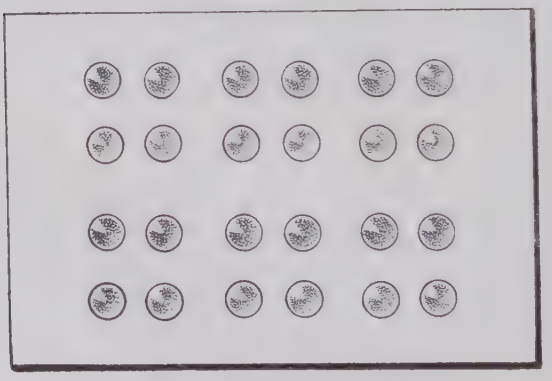

FIG. 4.

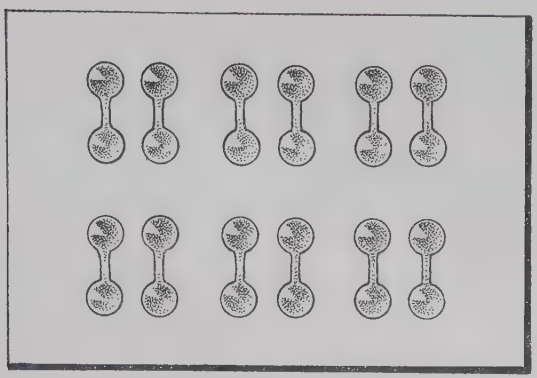

FIG. 5.

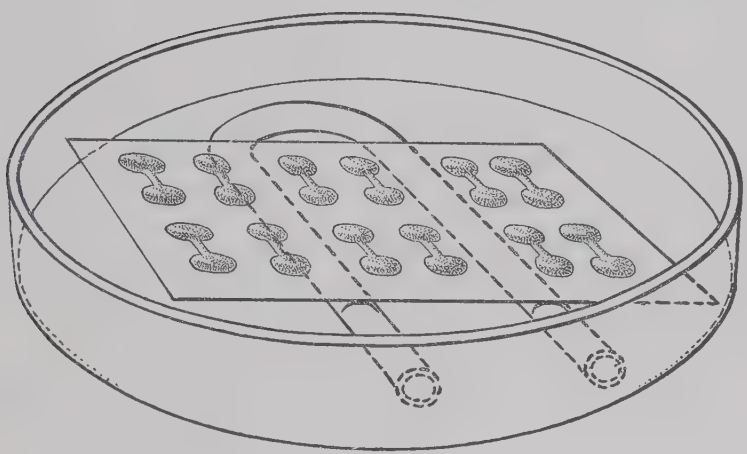

FIG. 6.

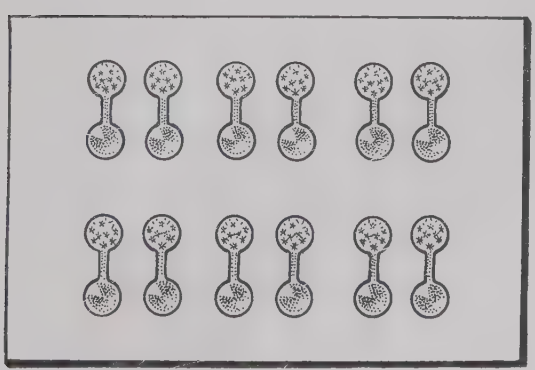

FIG. 7.

The wet chamber, with the cover glass in it, was left in the incubator for about twenty to thirty minutes. Then the slide was carefully removed and turned over on the chamber, the drops downward, and examined under the microscope. Clumps of bacteria at the union point of the two drops showed that agglutination was positive (fig. 7). The far end of the drop of bacterial emulsion, where serum did not reach, served as control. Motile bacilli which did not agglutinate in typhoid serum were tested out separately with paratyphoid A serum. Results were recorded.

Besides the agglutination tests performed with the colonies found suspicious on lactose methylene blue-eosin plates, these colonies were simultaneously transferred into Russell's medium and incubated for twenty-four hours. Results were recorded as follows: The tubes which showed much gas production and in which the medium was completely acidified were marked negative and discarded. Those which had no gas and in which the butt was acid were considered suspicious and were recorded as + Russell. Those which had gas but in which only the butt of the tube was acid were recorded as + and suspicious for paratyphoid A. The growth in Russell's tubes was then transferred into other carbohydrates to verify results and to determine the type of dysentery. The carbohydrates used for this purpose were glucose, mannite, maltose, xylose, dulcite, lactose, saccharose, and litmus milk.

Nonmotile bacilli, agglutinable in polyvalent antidysenteric serum 1:50 fermenting glucose alone or sometimes glucose and maltose (nonmannite fermenter), were reported positive for *B. dysenteriæ* Shiga. Nonmotile bacilli, agglutinable in polyvalent antidysenteric serum fermenting glucose, mannite, and maltose, but not lactose, were recorded as positive for *B. dysenteriæ* Flexner.

Motile bacilli, agglutinable by antityphoid serum, non-gas producer, fermenting glucose, mannite, and maltose, and turning lead acetate paper black, were recorded positive for typhoid.

Motile gas-producing bacteria fermenting glucose, mannite, maltose, and dulcite, and agglutinated by paratyphoid serum, were reported as positive for paratyphoid A.

SUMMARY OF RESULTS

1. Time of study, one year.

2. The number of specimens received for bacteriological examination in the search for *B. dysenteriæ*, *B. typhosus*, and *B. para-*

typhosus A in patients, healthy persons, and cadavers, and that were plated on lactose methylene blue-eosin agar, was 24,251; out of this number of specimens 441 were found suspicious on lactose methylene blue-eosin agar for either *B. dysenteriæ, B. typhosus,* or *B. paratyphosus A.*

3. Number of specimens found suspicious on lactose methylene blue-eosin agar for *B. dysenteriæ:*

Patients	66
Healthy persons:	
Food handlers	113
Contacts	50
Cadavers	6
Total	235

4. Number of specimens found suspicious for *B. typhosus* and *B. paratyphosus A:*

Patients	42
Healthy persons:	
Food handlers	101
Contacts	50
Cadavers	13
Total	206

5. Number of specimens obtained from patients and found suspicious on lactose methylene blue-eosin agar for either *B. dysenteriæ, B. typhosus,* or *B. paratyphosus A,* 108.

6. Number of specimens obtained from carriers and found suspicious on lactose methylene blue-eosin agar for either *B. dysenteriæ, B. typhosus,* or *B. paratyphosus A:*

Food handlers	214
Contacts	100
Total	314

7. Number of specimens obtained from cadavers and found suspicious on lactose methylene blue-eosin agar for either *B. dysenteriæ, B. typhosus,* or *B. paratyphosus A,* 19.

8. Number of specimens found suspicious on lactose methylene blue-eosin agar and confirmed as positive for *B. dysenteriæ:*

Patients	41
Healthy persons:	
Food handlers	11
Contacts	6
Cadavers	3
Total	61

9. Number of specimens found suspicious on lactose methylene blue-eosin agar and confirmed as positive for *B. typhosus:*

Patients	5
Healthy persons:	
Food handlers	0
Contacts	0
Cadavers	0
Total	5

10. Number of specimens found suspicious on lactose methylene blue-eosin agar and confirmed as positive for *B. paratyphosus A:*

Patients	4
Healthy persons:	
Food handlers	11
Contacts	4
Cadavers	2
Total	21

TABLES SHOWING THE RESULTS OF PRELIMINARY AND CONFIRMATORY TESTS OF BACILLUS DYSENTERIÆ, B. TYPHOSUS, AND B. PARATYPHOSUS A

FIGURES IN TABLES 1 TO 11 MEAN NUMBER OF SPECIMENS GIVING RESULTS CONFORMING WITH THE TESTS INDICATED ON THE LEFT OF EACH TABLE

TABLE 1.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.	
				Food handlers.			Contacts							
	B. dysenteriæ.	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*
Agglutination 1 : 1, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	26
Agglutination 1 : 50, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	26
Confirmatory, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	26

TABLE 2.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.	
				Food handlers.			Contacts.							
	B. dysenteriæ.	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus A.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*
Agglutination 1 : 1, positive	0	2	0	0	1	0	1	0	0	0	0	0	1	3
Agglutination 1 : 50, positive	0	2	0	0	1	0	1	0	0	0	0	0	1	3
Confirmatory, negative	0	2	0	0	1	0	1	0	0	0	0	0	1	3

TABLE 3.

Results of tests.	Specimens from patients.	Specimens from healthy persons.		Specimens from cadavers.	Total.
		Food handlers.	Contacts.		
Agglutination 1 : 1, positive	0	0	0	0	0
Agglutination 1 : 50, negative	0	0	0	0	0
Confirmatory, positive	0	0	0	0	0

TABLE 4.

Results of tests.	Specimens from patients.		Specimens from healthy persons.				Specimens from cadavers.		Total.	
			Food handlers.		Contacts.					
	B. dysenteriæ.	*B. typhosus* and *B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*
Agglutination 1 : 1, positive	19	1	76	14	34	15	3	1	132	31
Agglutination 1 : 50, negative	19	1	76	14	34	15	3	1	132	31
Confirmatory, negative	19	1	76	14	34	15	3	1	132	31

TABLE 5.

Results of tests.	Specimens from patients.	Specimens from healthy persons.		Specimens from cadavers.	Total.
		Food handlers.	Contacts.		
Agglutination 1 : 1, negative	0	0	0	0	0
Agglutination 1 : 50, negative	0	0	0	0	0
Confirmatory, positive	0	0	0	0	0

TABLE 6.

Results of tests.	Specimens from patients.		Specimens from healthy persons.				Specimens from cadavers.		Total.	
			Food handlers.		Contacts.					
	B. dysenteriæ.	*B. typhosus* and *B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus* and *B. paratyphosus A.*
Agglutination 1 : 1, positive	0	2	3	2	0	0	0	0	3	4
Agglutination 1 : 50 ±	0	2	3	2	0	0	0	0	3	4
Confirmatory, negative	0	2	3	2	0	0	0	0	3	4

TABLE 7.

Results of tests.	Specimens from patients.		Specimens from healthy persons.				Specimens from cadavers.		Total.	
			Food handlers.		Contacts.					
	Motile.	Nonmotile.	Motile.	Nonmotile.	Motile.	Nonmotile.	Motile.	Nonmotile.	Motile.	Nonmotile.
Lactose methylene blue-eosin agar, positive Agglutination 1 : 1, negative Agglutination 1 : 50, negative Confirmatory, negative	28	6	73	23	31	9	10	0	142	38

TABLE 8.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.		
				Food handlers.			Contacts.								
	B. dysenteriæ.	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*
Russell, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21
Other carbohydrates, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21

TABLE 9.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.		
				Food handlers.			Contacts.								
	B. dysenteriæ.	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*
Russell, positive	5	3	2	10	0	17	7	1	12	0	0	1	22	4	32
Other carbohydrates, negative	5	3	2	10	0	17	7	11	12	0	0	1	22	4	32

TABLE 10.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.		
				Food handlers.			Contacts.								
	B. dysenteriæ.	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*
Agglutination, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21
Russell, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21
Other carbohydrates, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21

TABLE 11.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.		
				Food handlers.			Contacts.								
	B. dysenteriæ.	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*	*B. dysenteriæ.*	*B. typhosus.*	*B. paratyphosus A.*
Agglutination, positive	5	3	2	10	0	17	7	1	12	0	0	1	22	4	32
Russell, positive	5	3	2	10	0	17	7	1	12	0	0	1	22	4	32
Other carbohydrates, negative	5	3	2	10	0	17	7	1	12	0	0	1	22	4	32

SUMMARY OF TABLES

Out of 24,251 specimens examined, 441 were found suspicious on lactose methylene blue-eosin agar plates for either dysentery, typhoid, or paratyphoid.

Table 1 gives the total number of specimens found positive for either dysentery, typhoid, or paratyphoid A, in both preliminary and confirmatory tests.

In Table 2, however, we find that a small number of specimens were positive on agglutination in both undiluted and diluted serum, but the result was negative on the confirmatory examination.

Not a single specimen, however, was found to give positive agglutination in undiluted serum, negative in diluted serum, and positive in confirmatory tests, as seen in Table 3.

Table 4 shows a number of specimens positive by agglutination with undiluted serum, but negative with diluted serum and in the confirmatory test.

Table 5 shows an important point; namely, not one of the specimens that would be negative on agglutination test with either diluted or undiluted serum would be found positive in the confirmatory test.

Table 6 shows a small number of specimens positive in agglutination in undiluted serum, slightly agglutinable in diluted serum, but negative in the confirmatory test.

Table 7 shows the number of specimens which gave suspicious colonies on lactose methylene blue-eosin agar plates but turned out to be negative in the agglutination and the confirmatory tests for either dysentery, typhoid, or paratyphoid A.

Table 8 shows that all specimens found positive in the confirmatory tests for either dysentery, typhoid, or paratyphoid A were positive in Russell's medium.

Several specimens were found positive in Russell's medium but resulted negative in other carbohydrates, as seen in Table 9.

Table 10 shows specimens which were positive in agglutination in Russell's and other carbohydrates. This table gives the same numbers as do Tables 1 and 8.

Table 11 shows a number of specimens which, although positive on agglutination and in Russell's, resulted negative in other carbohydrates.

CONCLUSION

From the tables it can be seen that, besides the number of specimens which were positive in both preliminary and confirmatory tests, there were some that, although positive in the preliminary tests, resulted negative in the confirmatory tests. On the other hand, however, none was found negative in the preliminary tests and positive in the confirmatory tests. So the error of the procedure here discussed lies on the safe side.

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ILLUSTRATIONS

TEXT FIGURES

THE PHILIPPINE SIGANIDS

By Albert W. Herre and Heraclio R. Montalban
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SIX PLATES

SIGANIDÆ [1] (TEUTHIDIDÆ)

Dorsal XIII–10; anal VII–9.

The oblong, strongly compressed form has a thick, leathery skin, covered with very small, closely adherent, cycloid scales, the caudal scaled, the other fins naked; the peculiar physiognomy is characteristic; the small mouth has one row of small, narrow, serrated cutting incisors in each jaw; the vomer and palatines are toothless; the dorsal fin is continuous, the spinous portion longer than the soft part; the dorsal and anal spines are strong, heteracanthous—that is, alternately strong and weak on the right and left sides; a sharp spine projects forward from the first interneural at the base of the first dorsal spine and pierces the skin at the nape, forming a prostrate spine; rarely it is concealed; the thoracic ventrals are unique, unlike those of any other fish, each with an outer and an inner spine, and with three soft rays between, I–3–I; the caudal fin is more or less lunate, never truncate. The gill membranes are not united, attached to the isthmus; pseudobranchiæ well developed; branchiostegals 5; the long intestine is much convoluted, with 5 or 6 pyloric cæca; the large air bladder is forked before as well as behind; vertebræ $10 + 13 = 23$. The skeleton has a number of peculiarities; the maxillary and premaxillary are firmly united, the lower pharyngeals but little developed; the abdominal cavity is surrounded by a complete ring of bones, the hypocoracoid extending backward the whole length of the abdomen and joined posteriorly to a spinous process of the first interhæmal; the long slender pubic bones are firmly attached to each other, with no free space between them.

[1] Starks, E. C., On the relationship of the fishes of the family Siganidæ, Biol. Bull. Marine Biol. Lab. Woods Hole 13 (1907) 211.

The family shows numerous peculiarities and stands rather far from any other known, but is apparently more closely related to the Acanthuridæ than to any other group. It is confined to the tropical parts of the Indian and Pacific Oceans, one species ranging northward to Japan. But two genera are known. The Siganidæ are small to moderate-sized fishes, not exceeding 400 millimeters in length, all herbivorous. The tail is unarmed, but they can inflict grievous wounds with their dorsal, anal, and ventral spines. They live about submerged reefs, feeding on the submarine pastures in great schools, like flocks of sheep. The larger species are excellent food fishes, the firm flaky flesh being well flavored. Some of them are dull colored, but a few kinds are very handsome.

Vast shoals of siganid fry approach the coast of Camarines Sur and Sorsogon each year, and are caught by the coast dwellers in large quantity. These fry are made into the fermented product called *guinamos* by the Bicols and Visayans, and *bagoong* by the Ilocanos. A similar phenomenon occurs on the coast of Pangasinan about Cape Bolinao.

Key to the Philippine genera of Siganidæ.

a^1. Snout slender, elongate, tubular..... **Lo.**
a^2. Snout of ordinary shape, not elongate or tubular..... **Teuthis.**

Genus TEUTHIS Linnæus

Teuthis LINNÆUS, Syst. Nat. ed. 12, 1 (1766) 507.
Siganus FORSKÅL, Descr. Anim. 10 (1775) 25.

The characters of the genus are included in the family diagnosis. About 30 nominal species are known, of which 15 are here described from the Philippines. A. B. Meyer collected in 1872 at Cebu a siganid which was determined as *Teuthis lurida* Rüppell, and published by him under that name in the Annales of the Natural History Society of Spain. This determination was probably an error, as *Siganus lurida* is otherwise known only from the Red Sea. Meyer's specimen was probably *S. fuscescens*. Some of the species are very handsomely colored or characteristically marked, but in most cases their colors disappear rapidly in alcohol. As the structure in this very natural genus presents but trifling differences, the determination of preserved specimens is often a matter of much difficulty.

Vernacular names: Bicol, *batawayi, turus;* Ibanag, *malaga;* Ilocano, *barangan;* Tagalog, *samaral;* Tao Sug and Samal, *bel-*

long, indongan; Visayan, *dayagbagu, danguit, layap, mandalada, samaral, tayog.*

Siganid fry are called *kuyug* in the Bicol language; *padas* in Pangasinan.

Key to the Philippine species of Teuthis.

a^1. No broad diagonal dark bands on head, no well-marked transverse bands or lines, and no extended longitudinal lines.

b^1. No large dark spot on shoulder.

c^1. Color uniform brown or mottled with darker brown; usually a few dark brown spots scattered over sides; caudal not deeply forked, barred with brownish; dorsal and anal rays not spotted. **T. fuscescens.**

c^2. More or less spotted with paler.

d^1. A large dark spot below dorsal rays; body with large spots, often hexagonal, golden or brown, rarely pale; three diagonal lines on side of head below eye, downward and forward. **T. concatenata.**

d^2. No large dark spot below dorsal rays.

e^1. Anterior and ventral parts and caudal peduncle covered with dark-edged, bluish, pearly ocelli, reduced to small dark spots or dots on trunk..... **T. corallina.**

e^2. Sides with rounded spots or short curved streaks, golden in life, often disappearing; caudal deeply forked, indistinctly barred with brown; dorsal and anal rays brown-spotted. **T. rostrata.**

b^2. A large dark spot on shoulder.

f^1. Head and body covered everywhere with large rounded or hexagonal golden or brown spots, larger than interspaces. **T. hexagonata.**

f^2. Spots smaller than interspaces.

g^1. Head and body with many pale spots, rounded and smallest on nape and dorsally, larger and oval or elongate on middle and ventrally; a blackish spot on top of eye; caudal not deeply forked..... **T. oramin.**

g^2. Entire body and fins dark purplish brown with a minute pearl white dot on each scale; caudal deeply forked..... **T. sutor.**

a^2. Broad diagonal dark bands on head, or body with well-defined transverse or longitudinal bands or lines.

h^1. A broad dark brown band from nape over eye to lower jaw.

i^1. Six undulate transverse blue bands anteriorly on body, longitudinal blue bands posteriorly, or blue bands broken and represented by dots..... **T. puella.**

i^2. A broad dark brown band from base of fourth to seventh dorsal spines to base of pectoral; both diagonal bands edged with bluish; top of head and interorbital with transverse blue or dark lines. **T. virgata.**

h^2. No broad diagonal band on head.
j^1. Transverse lines or bands on trunk.
k^1. Side with over twenty vertical bluish lines, often looped above and below, the anterior and posterior ones bent below and running back lengthwise below middle of side..... **T. doliata.**
k^2. Body with four broad transverse undulate dusky bands. **T. tetrazona.**
j^2. Sides with longitudinal lines.
l^1. Lines not vermiculated.
m^1. Bluish white lines along abdomen, passing into oblong elongate spots on middle of side and more or less rounded spots along back..... **T. javus.**
m^2. Nine or ten broad brown lines along side, forming isles and knots along back, interrupted on belly and passing into spots near anal; a large yellow spot under soft dorsal, sprinkled with black dots and circled by red..... **T. lineata.**
l^2. Lines vermiculated.
n^1. Depth 2.5 to 3 times in length; body covered with vermiculated bluish lines often reticulated, sinuously longitudinal along side; a dark crossband with narrow clear margins on base of caudal peduncle; caudal not spotted.... **T. striolata.**
n^2. Depth 1.9 to 2 times in length; entire head and body covered with vermiculate bluish white longitudinal lines; caudal fin spotted ..... **T. vermiculata.**

TEUTHIS FUSCESCENS (Houttuyn). Plate 1, fig. 1.

Centrogaster fuscescens HOUTTUYN, Acta Soc. Haarl. 20 (1782) 333.
Amphacanthus fuscescens CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 115; SCHLEGEL, Fauna Japonica, Pisces 127 (1842) pl. 68, fig. 1.
Teuthis fuscescens GÜNTHER, Cat. Fishes 3 (1861) 321; (?) JORDAN and METZ, Mem. Carnegie Mus. 6 (1913) 44.
Siganus fuscescens JORDAN and FOWLER, Proc. U. S. Nat. Mus. 25 (1902) 560, pro parte; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 98; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 247; SEALE, Philip. Journ. Sci. § D 5 (1910) 284; FOWLER, Proc. Acad. Nat. Sci. Phila. 70 (1918) 69; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 58.
? Teuthis lurida MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 22.

The slightly elongate body compressed and ovoid in form, upper and lower profiles about equally elevated and uniformly curved from snout to caudal peduncle, the greatest depth 2.5 to 2.6 in length; head a little longer than deep, 3.9 to 4.1 in length of body, its upper profile obtuse and very slightly arched; the slightly convex interorbital space widest in front, where there is a slight protuberance, its least width 3.2 to 3.5 in head; the diameter of the rounded eye 2.8 to 3.2 in head; the obtuse snout

2.3 to 2.4 times in head and 1.5 times maxillary, which is 3.4 to 3.6 in head; preorbital at angle of mouth very narrow, 2.4 to 2.8 in snout; about 18 teeth on each side in both jaws; upper teeth pointed, microscopically serrate, brownish tipped; lower teeth bifid, outer portion acutely pointed, inner part wider, higher, expanded in a very thin plate with a semicircular top; both nostrils rounded, the anterior one with a wide, rather high fleshy flap on its posterior margin, and the other a simple rounded opening; anterior edge of orbital ring finely serrated; preopercle margin entire, opercle unarmed; least depth of caudal peduncle 3.9 to 5.7 in length of head.

Only the cheek, and the uppermost portions of preopercle and opercle scaled, rest of head naked; caudal fin scaly and the other fins naked; middle dorsal spines highest, the last one 3 to 3.4 in head; anal spines increase in height to the third, from which they become lower to the last which is 2.5 to 3 in head; soft dorsal broadly rounded, its second and third rays highest, 1.9 to 2.1 in head; soft anal lower than dorsal, the rays decreasing in height posteriorly; the lunate caudal equals or is usually a little longer than head, 3.6 to 5 in length, 1.4 to 1.7 in depth, the upper lobe the longer; pectoral much shorter than caudal fin, 1.3 to 1.4 in head and 1.3 to 1.5 times ventral which extends but little beyond anus; outer ventral spine 3 to 3.25 in head, a little longer than inner one, which is 1.5 to 1.7 in pectoral.

The ground color of alcoholic specimens almost uniform brown, usually with a few dark brown spots scattered over sides of head and trunk, the dorsal region often darker, breast and posterior ventral region sometimes paler; some specimens have the sides mottled with darker brown; dorsal and anal clouded with brownish; caudal fin distinctly marked by brownish bars; pectoral uniform yellowish, ventral brownish.

This species is very abundant in some parts of the Philippines. The Bureau of Science collection contains 107 specimens, 25 to 170 millimeters long, from the following localities:

Higad, Camarines Sur, 4.
San Miguel Bay, Camarines Sur, 4.
Bacon, Sorsogon, 93.
Bantayan Island, 2.
Dumaguete, Oriental Negros, 2.
Sandakan, Borneo, 2.

The specimens from Higad, and 91 of the specimens from Bacon are from 25 to 30 millimeters long. Vast shoals of

kuyug, as the Bicols call the fry of this fish, approach the coasts of Sorsogon and Camarines Sur annually, during April and May. Large quantities are caught and preserved with salt to make guinamos. Our Philippine specimens all agree with Schlegel's figure except for the brownish crossbars on the caudal. The Sandakan specimens are silvery on the belly.

Evermann and Seale had specimens from San Fabian, Pangasinan; Bacon, Sorsogon; and Jolo. Seale and Bean had specimens from Zamboanga, and Fowler and Bean had one from Cebu; Fowler had a "large series, mostly young," from "the Philippines." Seale obtained it at Sandakan, Borneo.

This species is common in Japan, where it is caught in large quantities at nearly all times of the year, but its flesh is little esteemed. It does not attain a length greater than about 290 millimeters. It has also been reported from Korea.

Jordan and Fowler's account of *Siganus fuscescens* (Houttuyn) includes *T. albopunctatus* (Schlegel), a synonym of *T. oramin* (Bloch and Schneider); one of their Japanese specimens, 114 millimeters long, is in the Bureau of Science collection; it is typical *T. albopunctatus*, differing from *T. fuscescens* in having the small white spots or dots on the sides and a dark shoulder spot. Small specimens of *T. fuscescens* do not show these characteristics, but are colored like the adults. Jordan and Evermann's *Siganus fuscescens* from Formosa is also *T. albopunctatus*, or *T. oramin* according to our interpretation of this species. Specimens of *T. oramin*, but 20 to 25 millimeters in length, show the characteristic markings of that species and can at all times be separated from *T. fuscescens*.

TEUTHIS CONCATENATA (Cuvier and Valenciennes). Plate 4, fig. 1.

Amphacanthus concatenatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 93; BLEEKER, Act. Soc. Sci. Indo-Neerl. 1 (1856) Beschrij. visch. Amboina, 46; WEBER, Fische Siboga Exp. (1913) 330.

Teuthis concatenata GÜNTHER, Cat. Fishes 3 (1861) 316; Fische der Südsee 1 (1873) 88; DAY, Fishes of India (1878) 167, pl. 40, fig. 4.

Siganus concatenatus JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 789.

Siganus lineatus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 98.

Siganus lineatus JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271.

Siganus hexagonatus SEALE, Philip. Journ. Sci. § D 5 (1910) 284.

? *Amphacanthus tetrazonus* BLEEKER, Nat. Tijd. Ned. Ind. 8 (1855) 441.

? *Siganus tetrazonus* JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35.

Ibanag name at Buguey, Cagayan Province, *malaga*.

Depth of the oblong, much compressed body 1.9 to 2 in length; upper profile more elevated than ventral; length of head less than its depth, 3.4 to 3.7 in length of body; the very much elevated upper profile very steep in front of interorbital space and rather obtuse behind; the least width of the slightly arched interorbital is 2.9 to 3.1 in head and is slightly exceeded by the diameter of the large rounded eye, which is 2.7 to 2.9 in head; snout 2 to 2.1 in head and 1.7 to 1.8 times maxillary, which is 3.3 to 3.7 in head and reaches to below posterior nostril; preorbital width behind angle of mouth a little less than length of maxillary and almost twice in snout or 3.9 to 4.6 in head; the anterior nostril has a fleshy marginal flap behind; anterior edge of orbital ring finely serrated; angle of preopercle finely serrated and slightly produced, forming a very shallow notch with the vertical limb; opercle has an angular point behind; least depth of caudal peduncle 3.1 to 3.3 in length of head.

Scales cover cheek, and uppermost portions of preopercle and opercle, while the rest of head is naked; no scales on any of the fins except caudal; middle dorsal spines higher than the others, the last one 1.9 to 2.1 in head; anal spines evenly graduated to the last which is the highest and contained 1.2 to 1.3 in head; dorsal and anal rays angular and of almost the same height, each 1.2 to 1.4 in head; the moderately emarginate caudal 1.6 to 1.8 in depth, 2.8 to 3.35 in length, the upper lobe slightly the longer; pectoral shorter than head, 4.4 to 4.9 in length and 1.3 to 1.5 times ventral; the latter terminates a little in front of anal fin, its outer spine 1.6 to 1.97 in head, longer than inner one which is 1.96 to 2.33 in head.

Living specimens in the Bureau of Science aquarium are bluish with rounded or hexagonal golden spots on sides, which are much larger than the brilliant silvery bluish interspaces between them; there is a large, somewhat irregular golden or brown blotch below base of posterior dorsal rays; each side of head golden, with a bright silvery bluish line below preorbital, another one across cheek, a third at outer edge of scaly portion of preorbital, and a fourth near outer edge of opercle; spinous dorsal and all of anal fin golden brown; dorsal and anal

rays and caudal spotted with brown; pectoral and ventrals nearly colorless, or pectoral very pale yellow.

A badly frightened living specimen changed its color, so that it was darker and had four very large irregular dark brown spots above the middle of the side, and four dark brown bars inclined diagonally downward and forward across the whole width of dorsal and upon back below its base, alternating with the lateral spots, and a broad brown bar from origin of dorsal across eye to top of lip and middle of snout, where it joined its fellow from the other side.

When marked in this way it was much like *T. tetrazona* (Bleeker). I doubt the validity of the last-named species and believe that it is probably only a phase of *T. concatenata.*

The colors of alcoholic specimens vary as follows:

Ground color brownish, with golden brown spots on sides, the spots much larger and darker than the interspaces between them, closer together on upper half and often hexagonal and more widely spaced on lower half, especially posteriorly; vertical fins brownish violet with darker spots on their rays; caudal fin also brownish violet, spotted with darker brown; pectoral and ventral yellowish; a deep brownish violet line on lower edge of orbital, another one across cheek, and a third along lower edge of scaly portion of preopercle.

Other specimens are yellowish brown, with paler hexagonal spots which are much larger than the interspaces between them; a large brown blotch below base of posterior dorsal rays; dorsal and anal yellowish with a few brownish spots; caudal fin also yellowish and spotted lightly with brownish violet; a dark brownish violet line present below orbital, a second one across cheek, and a third on outer margin of scaly portion of preopercle; pectoral and ventral fins yellowish.

Still other specimens which are brownish have hexagonal or rounded spots which may be either darker or lighter than the ground color; the lighter spots were undoubtedly golden in life, and the darker ones probably golden brown. Either one or both kinds of spots may be present on the same individual; the ventral half may be silvery, and all the spots dark brown.

Specimens from Luna, La Union Province, are purplish brown, more or less silvery on the belly, with rows of large pale silvery gray spots, some larger than the pupil; a large silvery white spot below soft dorsal; the characteristic lines are on side of head; dorsal, anal, and caudal dusky purplish, the soft

dorsal rays and caudal spotted with dark violet-brown; pectoral very pale yellowish, ventral nearly colorless.

In life this is a very handsome fish. Long observation of living material has shown that the species is variable, individuals differing widely in size and color of the spots and the ground color, as well as in the presence or absence and color of the large spot below the soft dorsal. The blue lines on sides of head and the spots on vertical fins are constant, but may disappear in alcohol; the caudal spots are usually present, but sometimes are absent, even in living specimens.

The Bureau of Science collection contains 31 specimens, varying from 39 to 196 millimeters in length:

Buguey, Cagayan, 2.
Luna, La Union, 3.
Agno River, Pangasinan, 1.
Bolinao, Pangasinan, 3.
Hundred Islands, Pangasinan, 1.
Iba, Zambales, 1.
Manila, 3.
Nasugbu, Batangas, 1.
Puerto Galera, Mindoro, 2.
Mangarin, Mindoro, 1.
Bulan, Sorsogon, 1.
Guinobatan, Masbate Province, 1.
Catbalogan, Samar, 2.
Bantayan Island, 1.
Dumaguete, Oriental Negros, 2.
Cagayan de Misamis, Mindanao, 1.
Caldera Bay, Mindanao, 1.
Sandakan, Borneo, 4.

This species was listed from the south coast of Oriental Negros by Jordan and Seale, and under the name *Siganus lineatus* from Bacon and Bulan, Sorsogon, by Evermann and Seale, and from Aparri and Cuyo by Jordan and Richardson.

It is a handsome fish, occurring from the Andamans to the Pelew Archipelago, and is widespread in the East Indies. It attains a length of about 280 milimeters.

TEUTHIS CORALLINA (Cuvier and Valenciennes). Plate 1, fig. 2.

Amphacanthus corallinus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 101; SCHLEGEL and MÜLLER, Verh. Nat. Gesch. Ned., Leiden 2 (1844) 10, pl. 2, fig. 2.

Teuthis corallina GÜNTHER, Cat. Fishes 3 (1861) 316; Fische der Südsee 1 (1873) 88.

Siganus corallinus JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271; FOWLER, Proc. Acad. Nat. Sci. Phila. 70 (1918) 69; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 58.

The oblong compressed body rather deep, 1.9 to 2.3 in length, the profiles about equally elevated; length of head equals its height, 3.4 to 3.7 in length of body; a protuberance in front of eyes gives a slightly concave outline to snout; lower profile of head slightly concave; least width of the moderately convex interorbital about equal to eye, which is 3 to 3.2 in

head; snout 1.8 to 2 in head and twice the maxillary, which is 3.8 to 4 in head, its posterior end below anterior nostril; width of preorbital at angle of mouth 1.6 to 1.8 in length of snout; anterior nostril very small and circular, posterior one a little larger and covered in front with a fleshy membrane; angle of preopercle not much prolonged, its edge having fine serræ which are inconspicuous in some examples; front edge of orbital margin rather indistinctly serrated; opercle unarmed behind; least depth of caudal peduncle 3.3 to 4 times in head.

Top of head almost entirely naked; no scales present on interorbital space, snout, preorbital, lips, chin, and lower two-thirds of opercular bone; with the exception of caudal all the fins are also without scales; the middle dorsal spines higher than the rest, the last spine 1.9 to 2 in head, and lower than last anal spine, which is 1.5 to 1.8 in head; the soft portions of vertical fins angular, dorsal a trifle higher than anal, 1.5 to 1.8 in head; caudal fin deeply lunate, the lobes pointed, the upper one slightly the longer, from a little more than to a fourth longer than head, 1.3 to 1.4 in depth and 2.77 to 3.17 in length; the broad pectoral shorter than head, 4 to 4.2 in length and 1.2 to 1.5 times ventral, which extends about halfway between anus and origin of anal fin; inner ventral spine much shorter than outer one, 1.7 to 2 in pectoral, outer spine 1.6 to 1.9 in head.

In alcohol specimens are violet-brown or orange brown, the fins paler to yellowish white; head, breast, belly, and region immediately behind head covered with large dark-edged violet or bluish pearly ocelli, which become much smaller and cover the trunk as deep violet or dark spots or dots, much smaller than the interspaces, larger again at base of anal and caudal; sometimes the dots extend over the fins.

We have examined 14 specimens, 96 to 229 millimeters in length, from the following localities:

Olongapo, Zambales.
Ambil Island.
Sibuyan Island.
Tagapula Island, Samar Province.
Culion Island.
Bantayan Island and Cebu, Cebu.
Dulag, Leyte Province.
Zamboanga, Mindanao.
Jolo, Sulu Province.

Jordan and Richardson recorded this species from Cagayancillo, Fowler from "the Philippines," and Fowler and Bean had

specimens from Zamboanga. This handsome fish was originally described from the Seychelles where, according to Cuvier and Valenciennes, it prefers to live in the madrepore corals. It occurs throughout the East Indies, from Sumatra to the Moluccas, and eastward to the Pelew Islands.

TEUTHIS ROSTRATA (Cuvier and Valenciennes). Plate 1, fig. 3.

Amphacanthus rostratus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 116; KLUNZINGER, Fische des Rothen Meeres, Verh. Zool.-Bot. Ges. Wien 21 (1871) 503.

Teuthis rostrata PLAYFAIR, Fishes of Zanzibar (1856) 50, pl. 10, fig. 2; GÜNTHER, Fische der Südsee 1 (1873) 89, pl. 60.

Siganus rostratus SEALE, Occ. Papers Bishop Museum 1 (1901) 111; Occ. Papers Bishop Museum 4 (1906) 67; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 360; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 58.

Dorsal and ventral profiles of the elongate compressed body are evenly and about equally arched from snout to caudal peduncle, the greatest depth 2.5 to 2.8 in length; head a trifle longer than deep, its upper profile very slightly arched above snout, and almost straight or a trifle concave behind it, the length 3.8 to 4.4 in total length; interorbital space moderately convex, with a shallow groove along its middle extending forward to upper jaw, its least width almost equal to eye, which is 2.8 to 3.2 in head; snout longer than eye, 2.5 to 2.6 in head; maxillary extends posteriorly to a little past vertical from posterior nostril, 1.4 in snout, and about twice the width of preorbital at angle of mouth; teeth 12 or 14 on each side, bifid, outer lobe large, pointed, microscopically serrate, inner lobe very small, pointed; both nostrils rounded, the anterior one having a very high fleshy flap behind and the posterior one a fleshy membrane in front partly covering the opening; front edge of orbital ring finely serrated; preopercular angle entire and slightly produced; a rather conspicuous flat weak spine at posterior margin of opercle; least depth of caudal peduncle 4.3 to 5.3 in head.

Dorsal spines rather weak, the middle ones higher than the rest, the last being the lowest, 4.8 to 5.4 in head; anal spines decrease in height from second or third, the last one much lower than the first and contained 3.8 to 4.8 in head; dorsal and anal rays decrease in height to the last, the dorsal rays slightly the higher, 2.1 to 2.3 in head; caudal deeply forked, the upper lobe

the longer, a tenth to a fourth longer than head, or equal to head in small specimens, 3.4 to 3.75 in length and 1.3 to 1.4 in depth; pectoral shorter than head, in which it is contained 1.3 to 1.43 times; longest ventral ray a trifle longer than outer spine, which is 1.83 to 1.94 in head; inner spine shorter than outer one, 2 to 2.3 in head.

Alcoholic specimens violaceous brown, paler and more or less silvery beneath, sides with rounded spots or short curved streaks which were golden yellow in life, or the markings disappearing entirely; spinous dorsal and anal rather pale with brownish violet blotches, the rayed portions yellowish with brownish spots; caudal fin rather indistinctly barred with transverse brown bands; the pectoral is yellow and the ventral has some brownish violet blotches.

Here described from seven specimens, 90 to 190 millimeters in length, from the following localities: Balabac, 2; Samal Island, Davao, 1; Zamboanga, Mindanao, 4.

Jordan and Richardson had a specimen from Fuga Island, north of Luzon, and Fowler and Bean had four from Zamboanga.

Seale's color notes on a fresh specimen at Zamboanga are as follows: General color dusky blue with golden longitudinal lines more or less broken up into round spots, smaller than the interspaces, and becoming vertical behind the head; sides of head violet blue with ten irregular golden lines below eye; four brown crossbands on throat; dorsal bluish mottled with yellowish and dull brown, anal similar; pectoral golden; ventral bluish with some brownish blotches on the membrane; caudal grayish, barred marginally with darker.

The life colors of a Samoan specimen were sky blue, darker above, vermiculated with golden; dorsal mottled olive; caudal dusky, paler behind; anal dusky; ventral gray, barred with dark olive; pectoral golden.

This species, first collected in the Red Sea and afterward at Zanzibar, is not rare in the Society, Samoan, Gilbert, and Pelew Islands. It occurs also at Guam, the New Hebrides, the Solomon Islands, and Tubuai, one of the Austral Islands.

TEUTHIS HEXAGONATA (Bleeker). Plate 2, fig. 1.

Amphacanthus hexagonatus BLEEKER, Nat. Tijd. Ned. Ind. 7 (1854) 41; WEBER, Fische Siboga Exp. (1913) 328.

Teuthis hexagonata GÜNTHER, Cat. Fishes 3 (1861) 320; Fische der Südsee 1 (1873) 89.

Siganus hexagonata SEALE, Occ. Papers Bishop Museum 1 (1901) 111.

Siganus punctatus JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 360.

Depth of the oblong compressed body 2 to 2.2 in length; anterior dorsal and ventral profiles evenly and strongly convex, or upper profile steeper than ventral, or upper profile somewhat sinuous and lower in a bold uniform curve; head a little deeper than long, its upper profile a little steep and very slightly arched, 3.4 to 4 in total length; interorbital space markedly convex, its least width 2.9 to 3.2 in head and slightly greater than eye which is contained 3.1 to 3.6 times; snout 2 to 2.1 in head and 1.7 to 1.9 times maxillary, which is 3.5 to 3.9 in head and ends posteriorly below posterior nostril; width of preorbital at angle of mouth a trifle less than length of maxillary, 3.7 to 4.3 in head; anterior nostril small and rounded, having a fleshy rim which is highest posteriorly; posterior nostril a little larger and partly covered in front with a fleshy membrane; anterior edge of orbital margin distinctly serrated; angle of preopercle is slightly produced and forms a very shallow notch with the vertical limb, its edge entire; the opercle has an angular point at its hind edge; least depth of caudal peduncle 3.1 to 3.6 in head.

Head naked except on cheek, and on uppermost portions of preopercle and opercle; all the fins with the exception of caudal also naked; dorsal spines strong, the middle ones highest, the last one 2 to 2.5 in head; the very strong anal spines increase in height toward the last, which is 1.6 to 2 in head; soft dorsal and anal angular to angulose-rounded, of equal height, 1.3 to 1.8 in head; caudal fin deeply notched, apex of notch rounded, the upper one of the long pointed lobes the longer, the fin usually a third or nearly a third longer than head, rarely as short as head, 2.8 to 3.4 in length; the very broad pectoral nearly as long as head, 4.4 to 4.9 in length and 2.1 to 2.4 in depth of body; longest ventral ray does not quite reach origin of anal and is slightly longer than outer spine which is 1.6 times to nearly twice in head; inner ventral spine much shorter than outer one, about 2 to 2.3 in head.

Ground color in alcohol usually varies from brown to blackish brown, sometimes bluish gray, head, trunk, caudal peduncle, and caudal fin thickly covered with many pale, yellowish, brown, to dark brown spots as large as or a little larger than the interspaces between them, but smaller than pupil; the spots may be

rounded or oblong and are often more or less hexagonal through crowding, the ground color only forming a network between them; the spots may disappear along the ventral region from behind ventrals as far back as posterior extremity of anal, but often the lower part of belly and the region above anal are densely covered with intricately convoluted and vermiculate lines; a large irregular blackish blotch on shoulder; my smallest specimen, which is from Samal Island in Davao Gulf, and 3 small specimens from Tayabas have the shoulder spot surrounded by a broad white ring; vertical fins and ventrals uniformly violet-brown or blackish brown, or the soft dorsal and anal may be spotted with darker; pectoral uniformly yellowish or yellowish brown.

A fresh specimen from Samal Island was lilac-gray, the dorsal region and caudal peduncle darker and more bluish, a pearly blue wash over all; a coral red spot on shoulder above upper end of posterior margin of opercle; the entire body, including lips and eyes, covered with rounded golden spots, those on caudal smaller than elsewhere and yellowish brown; ventral margin of caudal violet; dorsal dusky brown, covered with reddish brown spots, the spinous part with a colorless margin, soft dorsal spotted all over; anal dusky, rays blue, membrane unspotted except margin of soft anal which was spotted like dorsal; ventral was brownish gray, pectoral with a yellowish cast.

The Bureau of Science collection contains 22 specimens, varying in length from 46 to 265 millimeters, collected at the following places:

Bolinao, Pangasinan, 3.
Olongapo, Zambales, 1.
Lucena, Tayabas, 3.
Calabanga, Camarines Sur, 3.
Calapan, Mindoro, 2.
Estancia, Panay, 1.
Bantayan Island, 2.
Cuyo Island, 1.
Dumaguete, Oriental Negros, 1.
Samal Island, Davao Gulf, Mindanao, 2.
Zamboanga, Mindanao, 1.
Pabalbag Island, Sulu Province, 1.
Sitankai, Sulu Province, 1.

This distinct and beautiful species is one of the largest siganids, reaching a length of over 300 millimeters. It was first described from Cocos Island, which lies in the Indian Ocean nearly 700 miles southwest of the western extremity of Java, and it is known from Sumatra and eastward throughout the East Indies to the Fiji and Samoan Islands. *Siganus hexagonatus* (Bleeker) may be the same as *S. punctatus* (Bloch and Schneider) after Forster's MSS., but this is doubtful. Fors-

ter's specimen came from New Caledonia and one should have ample material from that island in order to be certain just what fish he had.

TEUTHIS ORAMIN (Bloch and Schneider). Plate 5, fig. 1.

Amphacanthus guttatus var. *oramin* BLOCH and SCHNEIDER, Syst. Ichth. (1901) 207, pl. 48.

Teuthis oramin GÜNTHER, Cat. Fishes 3 (1861) 318; DAY, Fishes of India (1878) 168, pl. 40, fig. 6.

Siganus oramin JORDAN and SEALE, Proc. U. S. Nat. Mus. 38 (1905) 789; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271; SEALE, Philip. Journ. Sci. § D 9 (1914) 73.

Amphacanthus oramin WEBER, Fische Siboga Exp. (1913) 329.

Amphacanthus margaritiferus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 109.

Teuthis margaritifera GÜNTHER, Cat. Fishes 3 (1861) 317; DAY, Fishes of India (1878) 167, pl. 40, fig. 5.

Amphacanthus dorsalis BLEEKER, Verh. Bat. Gen. 23 (1850) 9.

Amphacanthus albopunctatus SCHLEGEL, Fauna Japonica, Pisces (1842) 128; KNER, Reise Novara, Fische (1865) 206.

Teuthis albopunctata GÜNTHER, Cat. Fishes 3 (1861) 318; Fische der Südsee 1 (1873) 88.

Siganus albopunctatus SEALE, Philip. Journ. Sci. § D 5 (1910) 284.

Local name at Iba, Zambales, *titang*.

Body moderately deep to slightly elongate, with dorsal and ventral profiles evenly and about equally arched from snout to caudal peduncle, depth 2.4 to 2.7 in length; upper profile of head a steep, straight, or nearly straight line from origin of dorsal to eye or beyond, thence convex to tip of snout; length of head a trifle greater than its depth, 3.8 to 4.1 times in total length; the least width of the slightly convex interorbital space a little less than eye, which is 2.6 to 3.4 in head; snout longer than eye, 2.4 to 2.6 times in head; the maxillary, which ends posteriorly a little past the vertical from posterior nostril, is 3.1 to 3.6 in length of head or 2 to 2.3 times width of preorbital at angle of mouth; two small nostrils in front of each eye, the anterior one more rounded and having a rather low fleshy flap on its posterior border; anterior border of orbital ring is finely serrated and has a rather sharp spine above it; the slightly produced angle of preopercle finely serrated; two flat weak spines at posterior edge of opercle; least depth of caudal peduncle 3.9 to 4.5 in head.

A few scales on cheek, and uppermost portions of opercle and preopercle, the rest of head naked; third to seventh dorsal spines higher than the rest, last spine rather low, 3.4 to 4.3 in head; second, third, and fourth anal spines highest, the last

one 2.5 to 3.4 in head; soft dorsal higher than anal rays, second or third ray highest, 2 to 2.4 in head; anal rays decrease in height from first or second, which is 2.4 to 2.7 in head; caudal more or less emarginate, sometimes appearing deeply forked when relaxed but never so when expanded, tips of lobes acute, the upper the longer; the fin longer than head, 3.45 to 3.75 in length, 1.3 to 1.5 in depth of body and 1.4 to 1.6 times pectoral, which is 1.25 to 1.35 in head; ventral fin extends halfway between anus and anal fin, its longest ray as long as or longer than outer spine, which is 1.78 to 1.94 in head; inner ventral spine 2 to 2.3 in head.

A fresh specimen was drab-gray, head and body thickly sprinkled with small yellowish white spots; dorsal and anal bluish, clouded with yellowish, spines gray, the yellowish rays spotted with brown, forming crossbars; caudal yellowish, with brown crossbars, tip dusky; ventral bluish, pectoral yellow; two dark crossbars on chin.

Another specimen was very light gray with a slight wash of yellowish, and pale bluish spots about half the size of pupil scattered all over head and body; three brown bars over throat and under chin; spinous dorsal bluish, spines gray, soft dorsal bluish, rays yellowish with brown blotches forming crossbars; spinous anal blue, barred with brown, soft anal yellowish, with four oblique crossbars of brown spots on rays; the yellowish caudal darker at tip and crossbarred with brown; pectoral yellowish, ventral bluish, with two pale brown crossbars.

A specimen sketched in color by the late T. S. Espinosa was grape green on sides and deep grape green along dorsal region, becoming olive yellow lower down and pale primrose yellow on breast, belly, and lower side of head; a dark spot on shoulder; entire body strewn with small pearly white spots much smaller than the interspaces, mere circular dots on nape and caudal peduncle, largest and more or less elongate along middle and lower part of body; the fins typically marked.

The color of another fresh specimen was pale brownish above, bluish below, the body covered everywhere with small pale blue spots considerably smaller than the interspaces; a yellowish brown spot on shoulder; caudal crossbarred with dark brown.

The ground color in alcohol is some shade of violaceous or plain brown or violaceous dusky, the whole body uniformly colored or the belly or lower half of body paler or silvery, snout, top and sides of head, and whole body sprinkled with many bluish

white or white or pearly spots, much smaller than the interspaces; the spots rounded and smallest on nape and along dorsal region, usually larger or much larger and more or less oval or elongate on middle and lower parts of trunk; many specimens have a few dark blackish brown rounded or irregular spots thinly scattered over sides; a large irregular dark brown blotch on shoulder; many specimens have two brown or dusky bands under chin; the spinous portions of dorsal and anal pale and clouded with brownish, the rays spotted with brownish or dusky; caudal fin with transverse bars of blackish or brown, which sometimes disappear in alcohol, especially after the lapse of some years; a blackish spot on upper edge of eye.

This species is abundant in the Philippines. We have examined 113 specimens, 20 to 218 millimeters long, from the following localities:

Burgos, Ilocos Norte, 2.
Anda, Pangasinan, 9.
Bolinao, Pangasinan, 3.
Iba, Zambales, 1.
Orani, Bataan, 1.
Manila, 5.
Cavite, 1.
Nasugbu, Batangas, 1.
San Miguel Bay, 1.
Calapan, Mindoro, 4.
Puerto Galera, Mindoro, 3.
Concepcion, Busuanga, 1.
Despujols, Tablas, 1.
Iloilo, Panay, 1.
Dumaguete, Oriental Negros, 6.
Bantayan Island, 1.
Cebu, Cebu, 1.
Inabanga, Bohol, 5.
Borongan, Samar, 1.
Cuyo Island, 1.
Canigaran, Palawan, 1.
Surigao, Mindanao, 4.
Cagayan de Misamis and Misamis, Mindanao, 4.
Caldera Bay, Mindanao, 5.
Zamboanga, Mindanao, 2.
Davao, Mindanao, 3.
Samal Island, Davao Gulf, 16.
Tubigan Island, Sulu Province, 2.
Bato-Bato, Tawitawi, 2.
Balabac, 3.
Sandakan, Borneo, 1.
Hoihow, Hainan, 5.
Hongkong, 14.
Amoy, China, 1.
Shimizu, Japan, 1.

Our largest specimen is a female nearly ready to spawn, collected March 12, 1927, at Misamis, Mindanao.

This species has been recorded by Günther under the name *Teuthis albopunctata* from the Philippine Islands, and from Manila by Kner under the name *Amphacanthus albopunctatus*. Jordan and Seale had six specimens from the southern shore of Negros, and Jordan and Richardson had the fish from Aparri and Cavite.

This variable species ranges from the eastern coast of Hindustan eastward throughout the East Indies, and along the

coasts of China and southern Japan and on to Micronesia, where it is recorded from the Pelew Islands and Howland Island, which lies east of the Gilbert Islands.

We are unable to separate specimens with smaller spots from those with larger ones, or those with more deeply emarginate caudal from those with the caudal but slightly emarginate. Many of our specimens are like Day's figure of *Teuthis margaritifera;* we have none like Schneider's Plate 48, or Day's poor figure of *T. oramin,* although we have many near the latter. Specimens from Borneo and the Sulu Archipelago are exactly like a specimen from Japan.

TEUTHIS SUTOR (Cuvier and Valenciennes). Plate 2, fig. 2.

Amphacanthus sutor CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 108.

Teuthis sutor GÜNTHER, Cat. Fishes 3 (1861) 317; DAY, Fishes of India (1878) 167.

Depth of the compressed body 2.1 in length, dorsal and ventral profiles similar and equally curved; head as long as deep, 3.8 to 3.9 in length; the convex interorbital 3.1 to 3.2 in head and slightly wider than eye, which is 3.2 to 3.3 in head; snout 2 to 2.2 times in head and nearly twice the length of maxillary, which is 3.6 to 4.1 in head; greatest width of preorbital almost equal to eye, 1.4 to 1.6 in snout; front nostril rounded, the fleshy rim highest behind; posterior nostril is a larger opening covered with a membrane in front; preopercle finely serrated at its angle and on its inferior limb; above angle a very slight notch; orbital margin finely serrated in front; opercle has two flat spines at its hind border, a small rather inconspicuous one above gill opening and a larger one a little below it; least depth of caudal peduncle exceeds slightly greatest width of preorbital, and is 2.9 to 3.1 in head.

Scales present on cheek, and on uppermost portions of opercle and preopercle, the rest of head naked, and all the fins excepting caudal naked; last dorsal spine about as high as middle ones, 1.7 to 1.9 in head; anal spines increase in height to the last which is 1.5 to 1.6 in head; soft dorsal and anal rounded, the former slightly the higher, the longest rays 1.4 in head; caudal fin deeply forked, with falcate lobes, the upper one slightly the longer and 1.4 to 1.5 times head; pectoral fin a little shorter than head, 1.1 to 1.17 in head and 4.2 to 4.6 in length; ventral extends to origin of anal, shorter than pectoral, 1.4 to 1.6 in

length of head; outer ventral spine about a fifth longer than inner one which is 1.9 to 2 in head.

The specimens when fresh were dark purplish brown, with a minute bright pearl white dot on each scale; there was a large blackish blotch on shoulder; all the fins were also dark purplish brown. The ground coloration has not changed much in alcohol.

Here described from three fine specimens, 167 to 182 millimeters long, taken at Guintacan and Bantayan Islands.

This is the first Philippine record of this species, which has heretofore been reported only from the Seychelles, Reunion, and the coast of Malabar.

This distinct and handsome species reaches a length of at least 280 millimeters.

TEUTHIS PUELLA (Schlegel). Plate 4, fig. 2.

Amphacanthus puellus SCHLEGEL, Bijdr. Dierk. 1 (1852) 39, fig. 2; BLEEKER, Act. Soc. Sci. Indo-Neerl. 8 (1860) 36; WEBER, Fische Siboga Exp. (1913) 329.

Teuthis puella GÜNTHER, Cat. Fishes 3 (1861) 323; BLEEKER, Ned. Tijd. Dierk. 1 (1863) 156, 235, 252; 2 (1865) 190, 288; Versl. Akad. Amsterdam II 7 (1873) 37; GÜNTHER, Fische der Sudsee 1 (1873) 91.

Amphacanthus cyanotaenia BLEEKER, Nat. Tijd. Ned. Ind. 4 Nieuwe Serie, 1 (1853) 606.

Siganus zoniceps SEALE, Occ. Papers Bishop Mus. 4 (1906) 69, fig. 18.

The compressed oblong body slightly elongate, depth 2.3 to 2.5 in length, dorsal and ventral profiles about equally elevated; head as long as deep, its length 3.5 to 3.8 in length, its upper profile somewhat obtuse and very slightly arched; least width of convex interorbital 3.1 to 3.5 in head, slightly greater than eye, which is 3 to 3.4 in head; the slightly elongate snout 2 to 2.1 in head and 1.7 to 1.8 in maxillary, which terminates posteriorly a little behind anterior nostril and is about as long as width of preorbital at angle of mouth; preopercle finely serrated at angle; front margin of orbital ring denticulate; a rather obscure flat weak spine at posterior edge of opercle.

Scales present on top of head a little in front of nape, on cheek, uppermost portion of preopercle and opercle, the rest of head naked; last dorsal spine 2.3 to 3 in head, much lower than last anal, which is 1.8 to 2.1 in head; in the young the posterior spines of dorsal higher than the rest, in the adult the middle ones highest; soft dorsal 1.5 to 1.8 in head, higher than anal,

which is 1.6 to 1.8 in head; caudal fin deeply lunate, its upper lobe slightly the longer, always longer than head, 2.92 to 3.3 in length, 1.5 to 1.8 times the broad rounded pectoral which is 2 to 2.2 in depth of body and 1.25 to 1.45 in head; ventral fin extends about halfway between anus and origin of anal, its outer spine much higher than the inner one and 1.2 to 1.5 in head.

Alcoholic specimens brownish violet, with six deep brown, somewhat vermiculated transverse lines on anterior portion of trunk and with longitudinal streaks of a like color posteriorly; a broad dark brown band crosses obliquely forward from nape over eye to lower jaw; on the upper portion of this band above eye are some darker or black spots, and behind it on preopercle a few brownish spots; fins yellowish to yellowish brown. The distinctive markings usually soon disappear in alcohol and the species is then very difficult to determine.

We have examined nine specimens, 121 to 227 millimeters long, obtained at Calapan, Mindoro; Simara Island, Romblon Province; Dulag, Leyte; Cebu, Cebu; Zamboanga, Mindanao; and Tawitawi and Bungau Islands, Sulu Archipelago.

Living specimens in the Bureau of Science aquarium, obtained at Calapan, Mindoro, are golden with a dark brown band from nape across eye to lower jaw; behind this a bright, clear, pale yellow band across opercle to throat and a dark band behind it; ventrals whitish, the other fins all golden, anterior anal margin golden brown; small faint blue spots thickly sprinkled over sides of head and anterior two-thirds of body.

Bleeker states that the color is dark orange above, orange on sides posteriorly, belly pearly rose with orange spots; anterior portion of sides with about six blue undulate transverse bands, posteriorly with several blue longitudinal bands, partly broken, united before shoulder with the last transverse band; snout olivaceous rose, opercle orange and clouded rose; a wide deep brown band from nape over eye to lower jaw; the fin membranes partly, the rays orange; the membranes of spinous dorsal and anal cloudy orange.

This species occurs from Celebes and Flores eastward to the Pelew and Gilbert Islands. Seale obtained specimens, which he described as *Siganus zoniceps*, at Shortland, one of the Solomon Islands.

TEUTHIS VIRGATA (Cuvier and Valenciennes). Plate 4, fig. 3.

Amphacanthus virgatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 97; SCHLEGEL and MÜLLER, Verh. Nat. Gesch. Leiden 2 (1839) 14, pl. 3, fig. 1.

Teuthis virgatus GÜNTHER, Cat. Fishes 3 (1861) 323.

Siganus virgatus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35; JORDAN and EVERMANN, Bull. Bur. Fisheries 26 (1907) 98; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 247; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271.

Cuyo name, *mandalada*.

Depth of the compressed, oblong body 1.9 to 2.2 in length, its dorsal and ventral profiles evenly and about equally arched from snout to caudal; head a trifle shorter than deep, 3.4 to 3.7 in length of body; the evenly convex interorbital more strongly arched in front, making the upper outline of snout straight and rather steep, its least width 2.8 to 3.4 in head; eye rounded, 2.7 to 3.5 in head; the moderate snout 1.2 to 1.8 times eye and 2 to 2.4 in head; maxillary extends almost below posterior nostril and is 1.6 to 1.9 in snout or 3.4 to 3.9 in head; width of preorbital behind angle of mouth 3.4 to 4.2 in head; in front of each eye two small rounded nostrils, the anterior having a low fleshy rim; the finely serrated angle of preopercle almost even with inferior and vertical edges; posterior margin of opercle has a flat, rather weak spine; least depth of caudal peduncle 3.3 to 3.7 in length of head.

Head unscaled above and on snout, orbital ring, jaws, chin, edges of preopercle, and lower three-fourths of opercle; all the fins excepting caudal are also naked; spinous dorsal highest along middle, the last spine 1.8 to 2.2 in head; the middle anal spines about as high as the last, which is contained 1.5 to 1.7 in head; the soft vertical fins very slightly angular, dorsal a little higher, 1.4 to 1.8 in head; caudal emarginate, upper lobe much longer than lower, its length greater than that of head, usually 2.7 to 3 times, rarely 3.3 to 3.5 times in total length; caudal 1.2 to 1.4 times the broad pectoral which is a little shorter than head and 1.8 to 2.2 in depth of body; ventral fin scarcely reaches origin of anal, 1.5 to 1.66 in head, 1.3 to 1.5 in pectoral; outer ventral spine nearly as long as longest ventral ray and much longer than inner spine which is about 2 to 2.4 in head and 1.6 to 2.2 in pectoral.

In the Bureau of Science aquarium are living specimens from Calapan, Mindoro, which are colored as follows: A wide red-

dish brown band extends diagonally forward from origin of dorsal through eye to below mouth, and a similar one of like color from base of fourth to sixth dorsal spines to base of pectoral; these bands are edged with bluish and the space between them is silvery white, as is the region in front of anterior band; color of trunk yellow on upper posterior portion, passing into silvery below and anteriorly immediately behind the posterior reddish brown band, and is overlaid with very light olive; spinous dorsal and entire anal clouded with brownish, soft dorsal yellow; a broad white crossband on caudal peduncle; caudal yellow with a white line on posterior margin, the other fins pale; several diagonal bluish lines on anterior portion of trunk and on each side of head, some of them on the reddish brown bands; bluish spots present also on each side of body and more numerous anteriorly above lateral line; top of head and interorbital crossed by several transverse blue lines.

Alcoholic specimens are yellowish brown or violet-brown, with deep brown transverse lines on forehead and nape; on upper portion of trunk are scattered bluish spots which become less numerous posteriorly; a wide deep brown band runs diagonally downward and forward from origin of dorsal through eye and below jaws to throat, where it joins its fellow, and a second one from sixth and seventh dorsal spines to base of pectoral, both bands edged with bluish; some bluish oblique streaks on snout; all the fins unmarked and lighter in color than body.

Of this species we have examined specimens ranging in length from 30 to 190 millimeters, from the following localities:

Balaoan, La Union, 1.
Bolinao, Pangasinan, 3.
Olongapo, Zambales, a ripe female, 159 millimeters long, collected April 7, 1921.
Monja Island, Corregidor, 2.
Calabanga, Camarines Sur, 1.
Puerto Galera, Mindoro, a ripe female, 190 millimeters long, taken in April, 1912.
Calapan, Mindoro, 35.
Bulalacao Bay, Mindoro, 1.
Masbate Island, 2 females in near-spawning condition, taken June 2, 1922.
Bantayan Island, 5.
Cebu, Cebu, 1.
Inabanga, Bohol, 1.
Dumaguete, Oriental Negros, 2.
Cuyo Island, 1.
Puerto Princesa, Palawan, 2.
Balabac Island, 2.
Samal Island and Zamboanga, Mindanao, 5.
Bungau, Sulu Archipelago, 2.

This fish has been recorded from the Philippines by Günther; from Panay Island by Jordan and Seale; from Cuyo by Jordan and Richardson; from Bacon, Sorsogon, by Evermann and Seale;

and from Zamboanga by Seale and Bean. It is very common around reefs in all parts of the Philippines.

It is known from the Andamans to the Malay Archipelago and ranges northward to the coast of China.

TEUTHIS DOLIATA (Cuvier). Plate 2, fig. 3.

Siganus doliatus CUVIER, Régne Anim. Guérin, Icon. Poiss. 4 (1830) pl. 36, fig. 1; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 359.

Amphacanthus doliatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 96; CUVIER, Régne Anim. Disciples' ed. Poiss. Atlas 8 (1836) pl. 71, fig. 1; KNER, Novara Reise, Fische (1865) 209.

Teuthis doliata GÜNTHER, Cat. Fishes 3 (1861) 323; Fische der Südsee 1 (1873) 90; PETERS, Monatsber. Akad. Wiss. Berlin (1876) 835.

Depth of the oblong appressed body 2.1 in length; head shorter than deep, 3.6 in length, upper profile rather conspicuously arched in front of eyes, giving a moderately steep and straight outline to snout; the slightly convex interorbital 3.3 in head and slightly narrower than eye, which is 2.9 in head; snout 2.2 in head and 1.8 times maxillary, which reaches nearly below posterior nostril; width of preorbital at angle of mouth 4.3 in head and twice in snout; 14 brown tridentate teeth on each side in both jaws, the central point of each tooth large, the lateral ones very small; the two nostrils in front of each eye simple rounded openings; angle of preopercle a little prolonged and finely serrated; orbital ring finely serrated in front; a flat weak spine at posterior edge of opercle; depth of caudal peduncle equal to least width of interorbital space.

Scales absent above and behind eyes, on snout, preorbital, lips, chin, edges of preorpercle, and opercle; all the fins excepting caudal also naked; middle dorsal spines higher than the rest, the last one twice in head; the anal spines increase in height to the last which is 1.7 in head; both soft dorsal and anal angular and equal in height, their longest rays 1.5 in length of head; the moderately concave caudal a trifle longer than head; pectoral shorter than head and about twice in depth of body; ventral fin reaches nearly to origin of anal, its rays 1.6 in head and 1.3 in pectoral, its outer spine longer than the inner one, 1.7 in head, the inner spine 1.95 in head.

Color in alcohol dark brown dorsally, paling to creamy and very pale brown on sides of head and breast; ventral half of side pale olive buff; sides with more than twenty vertical bluish lines, many of them looped above and below, the anterior and posterior ones bent below and running longitudinally backward

below middle of side and along lower part of caudal peduncle; some of the lines on posterior half reticulated; dorsally the lines fade to dark brown; top of head and snout barred by transverse lines, side of head obscurely barred and reticulated.

Here described from the only specimen in the Bureau of Science collection, 141 millimeters long, collected at Puerto Princesa, Palawan. This fish, which is new to the Philippines, is known from the Moluccas, the New Hebrides, Santa Cruz, Pelew, Caroline, Fiji, and Society Islands.

TEUTHIS TETRAZONA (Bleeker).

Amphacanthus tetrazona BLEEKER, Nat. Tijd. Ned. Ind. 8 (1855) 441.
Teuthis tetrazona GÜNTHER, Cat. Fishes 3 (1861) 323.
Siganus tetrazonus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35.

The body is oblong, compressed, the height between the first dorsal spine and the anterior ventral spine about 3, between the 7th dorsal spine and the first anal spine about two and three fifths in its length, breadth 3 to 3⅓ in its height; the head almost 4 in the body length, scarcely longer than high; the rostro-dorsal line concave on top of the snout, convex before the eyes; the diameter of the eye about 2⅔ in the length of the head; the orbital bones denticulate; the interocular line is slightly convex; the snout is sharp, without the superior maxilla shorter than the eye; teeth on each side of the maxilla about 24, below the emarginate apex subtrilobate; the suborbital bone at the angle of the mouth shorter than the diameter of the eye; the opercle and preopercle scarcely or not striated; the scales are very small, hardly noticeable behind the shoulder girdle, the others uniform; the lateral line is of subcontiguous tubules, each tubule characterized by a toothless branch above; the first dorsal scarcely notched between the spinous and rayed part, the spines large, the 9th and 10th longer than the others, about 2⅔ in the body height, the first shorter than the others; the soft dorsal a little lower than the spinous dorsal, obtusely rounded; the pectoral tip acutely rounded, about 5½, the ventral about 7, the caudal a little notched, the lobes rounded, about 5⅔ in the length of the body; the anal spines strong, the posterior ones longer than the others, the soft part convex and scarcely higher; the color of the body and fins beautiful yellow; the back with 4 pairs of transverse undulate dusky bands descending below the middle of the side, the anterior band about under the third dorsal spine, the second under the seventh and eighth dorsal spines, the third under the eleventh and twelfth dorsal spines, the fourth under the third and fourth dorsal rays. (*Bleeker.*)

The length given in the above measurements evidently includes the caudal fin. Jordan and Seale had 3 small specimens from Manila and 2 from Cavite, the largest 128 millimeters long. Their description follows, the caudal not included:

Head 3.5 in length; depth 2.1; eye 3.1 in head; snout 2.5. Color in spirits bluish white, with 4 broad cross-bands of dusky over back and down one side; base of caudal dusky; fins splotched with dusky.

The Bureau of Science collection contains ten immature specimens, 21 to 25 millimeters in length, collected by Alvin Seale at Zamboanga, Mindanao, and determined by him as *Siganus tetrazonus*. They are uniform brown except on the breast and belly, which are bright silver; the opercles also have a silvery sheen; some of them show the four dusky bands inclined diagonally forward, much as described by Bleeker, but most of them have only dusky spots along the base of the dorsal, the rest of the bands having faded.

Bleeker had one lone specimen, 64 lines (about 133 millimeters) long, from Manado, Celebes.

We doubt the validity of this species. It is probably a color phase of *T. concatenata*, as indicated in our remarks under that species.

TEUTHIS JAVUS Linnæus. Plate 5, fig. 3.

Teuthis javus LNNÆUS, Syst. Nat. ed. 12 1 (1766) 507; GÜNTHER, Cat. Fishes 3 (1861) 315; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 22.

Amphacanthus javus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 86.

Siganus javus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 98; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 57.

The greatest depth of the compressed, ovate-oblong body is at origin of anal fin, 2.1 to 2.3 in length, back and abdomen evenly and equally arched from snout to caudal peduncle; length of head equals its depth, 3.6 to 4.2 in total length, upper profile steeply inclined, forming a straight or nearly straight line from origin of dorsal to tip of snout; interorbital space is moderately convex and has a central shallow groove which narrows anteriorly, its least width 2.9 to 3.3 in head; the rounded eye 2.7 to 3.5 in head, anterior edge of orbital ring serrated; the obtuse snout 2.4 to 2.6 in head and 1.4 to 1.6 in maxillary, which is contained 3.5 to 3.9 in head and extends posteriorly to below posterior nostril; width of preorbital at posterior end of maxillary 2.3 to 2.8 in length of snout or 5.6 to 7.2 in that of head; the two nostrils in front of each eye small, the anterior one rounded and having a fleshy flap behind; preopercle somewhat indistinctly serrated at its angle; opercle armed with a flat weak spine at its hind border; least depth of caudal peduncle 3.5 to 4 in length of head.

Head scaled on cheek, uppermost angle of preopercle behind eye, and upper part of opercle, the remaining portions naked; fourth dorsal spine highest, equal to head without snout, the last one 2.1 to 2.9 in head, equal to or a little more or less than snout; third and fourth anal spines higher than the rest, seventh or last spine 1.7 to 2.1 in head; both soft dorsal and anal rounded, the former slightly the higher, its longest rays 1.5 to 1.8 in head; the lunate caudal longer than head, 3.1 to 3.7 in length, its lobes equal; pectoral shorter than head and 1.4 times ventral, which reaches a little more than halfway to anal; outer spine of ventral 1.75 to 1.9 in head, longer than inner one which is contained 1.8 to 2.4 in pectoral.

Ground color of living specimens in the Bureau of Science aquarium, collected at Calapan, Mindoro, is greenish, with large, more or less rounded bluish white spots along back, these becoming elongated on sides, confluent and forming longitudinal streaks and stripes on abdomen, narrower than the interspaces; caudal fin dusky with darker edges, the other fins light orange; ventral spines white.

In alcohol the ground color is brown, becoming much lighter on abdomen; on head and back many bluish white rounded spots, becoming oblong on middle of sides, elongated, confluent, and forming longitudinal lines on abdomen; vertical fins and caudal uniformly brownish violet; pectoral and ventrals yellowish; in one specimen all the fins are blackish.

We have examined 21 specimens in the Bureau of Science collection, ranging from 33 to 280 millimeters in length, from the following localities: Olongapo, Zambales; Malabon, Rizal Province; Manila; San Miguel Bay and Calabanga, Camarines Sur; Pinamalayan, Mindoro; Catbalogan, Samar; Estancia, Panay; Dulag, Leyte; Dumaguete, Oriental Negros; Balabac Island; and Sandakan, Borneo.

Meyer collected specimens from Manila Bay and at Cebu; Jordan and Seale had it from Cavite; Evermann and Seale from Bulan, Sorsogon; Jordan and Richardson from Manila and Cebu; and Fowler and Bean from Cebu.

This well-defined species occurs from Ceylon to Hobson Bay, near Melbourne, Australia.

TEUTHIS LINEATA (Cuvier and Valenciennes).

Amphacanthus lineatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 95, pl. 286.

Teuthis lineata GÜNTHER, Cat. Fishes 3 (1861) 322.
Siganus lineatus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35.

The height of the body is two and a half times in the length, and the head four times and a half. The spines are of moderate height, and the tail feebly cut into a crescent; the spines are very strong and striated. In alcohol it appears brown, but clear towards the belly, with longitudinal lines little evident and dark brown spots on the tail. Three or four oblique bluish lines show under the eye and on the jaw. In the fresh state, according to the naturalists who found it and whose description we cite, it is of a bluish white. The tawny longitudinal lines traverse its length to the number of 9 or 10, forming upon the back isles and knots, interrupted on the belly and reduced to dots near the anal; upon the head the lines are alternately reddish and blue, descending obliquely forward. The spinous part of the dorsal and anal is yellowish; the soft part and likewise the caudal are purplish brown; reddish or brown spots are sprinkled upon the end of the caudal peduncle, the caudal, and the soft dorsal and anal. The ventrals and pectorals are yellowish. The back has a large yellow spot under the soft dorsal, sprinkled with smallblack dots and surrounded by a red circle. (*Valenciennes.*)

The length given in the above measurements evidently includes the caudal. According to the figure the depth is twice in the length without the caudal, the head almost 4 times. Jordan and Seale had a specimen, about 145 millimeters long, from Manila; their description is as follows:

Head 3.75 in length; depth 2; eye 3 in head. Color in spirits bluish gray with brown dots or lines, the lines on upper part of body usually surrounding light bluish spots, some specimens (not all) showing a yellowish blotch at base of soft dorsal, and corresponding in every respect to the figure of Cuvier and Valenciennes (Hist. Nat. Poiss., plate 286); belly yellowish white; fins with grayish wash. One specimen from Manila, length 5.75 inches.

While there is a discrepancy in their account, it is evident that they had one specimen of *T. lineata.* We have seen no specimens of this species, which is readily recognized by the conspicuous coloration of the spot under the soft dorsal, and the lines on the sides of the body. Except for the Manila specimens, it is only known from Vanicolo, one of the Santa Cruz islands, where it is common, and from New Guinea.

TEUTHIS STRIOLATA Günther. Plate 5, fig. 2.

Teuthis striolata GÜNTHER, Cat. Fishes 3 (1861) 319; Fische der Südsee 1 (1873) 89, text only.
Siganus striolatus SEALE, Occ. Papers Bishop Mus. 4 (1906) 69.
Amphacanthus striolatus WEBER, Fische Siboga Exp. (1913) 329.
Siganus marmoratus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35; ? JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271.

Depth of the compressed, rather elongate body 2.5 to 3 in length, both dorsal and ventral outlines evenly and about equally curved from snout to caudal; the head is very slightly arched above and has a somewhat conspicuous swelling in front of eyes, causing the upper profile of snout to be steep; length of head equal to its height, 3.7 to 4.1 in total length; interorbital space almost flat, its least width 3.3 to 3.8 in head; the rounded eye slightly shorter than snout, 2.6 to 2.9 in head, edge of orbital ring entire; snout broad posteriorly and rather short, 2.4 to 2.6 in head; maxillary, which extends back a little behind a vertical from posterior nostril, shorter than snout, 2.4 to 2.9 times width of preorbital at angle of mouth; the two nostrils in front of each eye rounded, the anterior one slightly the smaller and having a very high, rather wide fleshy flap behind; angle of preopercle has a few indistinct serræ at its edge and forms a very shallow notch with the vertical limb; a flat, weak spine fairly conspicuous on posterior edge of opercle; least depth of caudal peduncle 3.8 to 4.6 in head.

Cheek, uppermost portions of opercle, and preopercle covered with scales, the rest of head naked; caudal fin thickly scaled near base, the other fins naked; dorsal spines of moderate strength, the middle ones the highest, the last spine 2.6 to 3.1 in head; middle anal spines the highest, the last one 2 to 2.5 in head; both soft dorsal and anal rounded, the former a little higher and contained 1.6 to 1.7 in head; the slightly emarginate caudal shorter than head, 1.5 to 1.7 in depth of body, 1.09 to 1.21 in head; the broad pectoral still shorter than caudal fin, 1.2 to 1.38 in head and 1.2 to 1.5 times ventral fin, which reaches about halfway between anus and origin of anal; outer ventral spine 1.63 to 1.9 in head, longer than inner one, which is 1.4 to 1.7 in pectoral, 1.8 to 2.1 in head.

Living specimens in the Bureau of Science aquarium, collected at Calapan, Mindoro, are greenish on upper half of body, whitish on lower half, and are covered all over with brilliant bluish vermiculated lines; there are transverse bluish lines on caudal peduncle; dorsal and anal yellowish, their rayed portions spotted with brownish; caudal fin mottled with yellowish and dusky, its upper, lower, and hind margins darker; both pectoral and ventrals whitish.

Color in alcohol brownish to rich reddish or blackish dark brown, paler to bluish ventrally, covered with many narrow vermiculated lines which often anastomose to form reticulations, especially dorsally, and become sinuously longitudinal along

sides, usually more or less vertical below soft dorsal and on caudal peduncle; a dark crossband on base of caudal peduncle, bounded by a narrow clear crossband on each side; dorsal spines vaguely spotted, spinous dorsal and anal clouded with brown or with a vague longitudinal band of brown or violet-brown; soft dorsal and anal crossbanded by alternate rows of brownish or dark brown and pale spots; caudal barred by four or five irregular dark crossbands, distinct on upper and lower margins but usually vague within; pectoral yellowish to almost colorless; only one or two specimens have the fins unspotted and all show bars on caudal; some have a very dark crossbar on base of caudal fin.

We have examined 41 specimens, 36 to 155 millimeters in length, from the following localities:

Luna, La Union, 4.
Nalvo, La Union, 2.
Paraoir, La Union, 2.
Bolinao, Pangasinan, 5.
Calapan, Mindoro, 9.
Pinamalayan, Mindoro, 5.
Bantayan Island, 1.
Tacloban, Leyte 1.
Canigaran, Palawan, 6.
Dumaguete, Oriental Negros, 1.
Zamboanga, 3.
Guam, 2.

Jordan and Seale had a specimen from Manila which was evidently this species, and Jordan and Richardson had one from Calayan which was probably *Siganus striolatus*. It has been recorded from the New Hebrides, Solomon, Samoa, Friendly, and Society Islands by Günther, and from the Society Islands by Seale; Weber obtained it at Obi Major, one of the Moluccas, and Biaru, one of the Sangir group.

From *T. marmorata*, with which it has been confused, it may be distinguished by the narrow vermiculated lines, which are broader than the interspaces in *T. marmorata*, and by the presence of the characteristic crossbars on the caudal peduncle and caudal fin.

TEUTHIS VERMICULATA (Cuvier and Valenciennes). Plate 3, fig. 1.

Amphacanthus vermiculatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 92; BLEEKER, Verh. Bat. Gen. 23 (1850) Teuthieden, 11; WEBER, Fische Siboga Exp. (1913) 326.

Teuthis vermiculata GÜNTHER, Cat. Fishes 3 (1861) 317; DAY, Fishes of India (1878) 166, pl. 40, fig. 1.

Siganus vermiculatus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 98; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 248; SEALE, Philip. Journ. Sci. § D 5 (1910) 283.

The compressed oblong body rather deep, its depth 1.9 to 2 in length, dorsal and ventral profiles evenly and equally arched;

head as deep as long, 3.3 to 3.7 in length, 1.7 to 2 in greatest depth of body, its upper outline slightly arched in front of eyes; width of the slightly convex interorbital 2.8 to 3.2 in head; the rounded eye 1.3 to 1.7 in snout, which is 2 to 2.3 in head; maxillary extends almost below posterior nostril, 3.3 to 3.6 in head; width of preorbital at angle of mouth less than length of maxillary and about twice in snout; two small nostrils present before each eye, the anterior one rounded and the other a crescentlike slit; preopercle finely serrated at its angle, which is slightly produced behind; a flat hidden spine present at posterior edge of opercle; front edge of orbital ring with fine but rather strong teeth; least depth of caudal peduncle 3.2 to 3.3 in length of head.

Head naked above and behind eyes, on snout, preorbital, lips, chin, limbs of preopercle, and opercle; caudal fin scaly, especially near base, all the other fins naked; dorsal spines rather strong, the last one highest, 1.7 to 1.8 in head; anal spines evenly graduated to the last which is the highest, 1.4 to 1.5 in head; the soft vertical fins rounded and equal in height, the longest rays 1.2 to 1.3 in head; caudal fin slightly emarginate, the lobes equally forked, 3.5 to 4.1 in length of body; pectoral fin less than half the greatest depth of body, 1.2 to 1.3 in head, and much longer than ventral which scarcely reaches anal fin; outer ventral spine longer than inner one, 1.5 to 1.6 in pectoral, 1.75 to 2 in head.

In alcohol the ground color is brown, nearly white on belly; the entire head and trunk covered with vermiculated bluish white lines, running longitudinally; vertical fins brownish violet with darker spots near their base; caudal fin spotted all over with violet-brown; pectoral uniformly yellowish and ventrals slightly washed with violet.

Here described from forty-six specimens, 27 to 164 millimeters long, collected at the following places: Burgos, Ilocos Norte; Luna, La Union; Agno River, Pangasinan; Biga-a River and Legaspi, Albay; Jordan, Guimaras Island; Cabalian, Leyte; Loay, Bohol; and Zamboanga and Davao, Mindanao. The Bureau of Science collection also has a fine large specimen, 211 millimeters long, from Sandakan, Borneo.

Günther recorded this species from the "Philippine Islands;" Evermann and Seale listed it from San Fabian, Pangasinan, Bacon, Sorsogon, Zamboanga, and "the Philippines;" Seale and Bean had specimens from Zamboanga.

Elsewhere it is known from Isle de France throughout the East Indies to New Guinea, and eastward to the Solomon and Admiralty Islands. It attains a length of at least 290 millimeters.

Genus LO Seale

Lo SEALE, Occ. Papers Bishop Mus. 4 (1906) 71.

From *Siganus*, to which *Lo* is very close, indeed, the latter can be distinguished at a glance by the slender, elongate, laterally flattened, tubulate snout which forms a short beak, and by the depressed anterior profile, which impart an aspect altogether different from that of any other siganid, all the rest having a more or less convex profile to the head. The shape of the body is also different, being more rectangular. Pyloric cæca 3 + 2, one on each side very small. In other respects it does not diverge materially from *Siganus*. Both of the species of *Lo* are of singular beauty.

Key to the species of Lo.

a^1. A large blackish lateral spot below base of posterior spines and anterior rays of dorsal ..... L. unimaculatus.
a^2. No large dark lateral blotch on body ..... L. vulpinus.

LO UNIMACULATUS Evermann and Seale. Plate 3, fig. 2.

Lo unimaculatus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 99, fig. 19.

Body compressed and moderately elongate with upper and lower profiles nearly parallel from origin of dorsal to origin of rayed dorsal, its greatest depth 2.1 in length; head produced and longer than deep, its length 3.1 to 3.2 times in that of body and its upper outline a little concave; the unevenly and slightly convex interorbital very slightly wider than eye which is contained 3.9 to 4 in head; the elongate tubular beaklike snout 1.8 in head and 2.7 to 2.8 times maxillary which is about 5 in head; mouth small, terminal, with about 12 teeth on each side of both jaws, those of upper jaw brown-tipped, those of lower jaw smaller and plain white; preorbital 1.3 in snout or 2.3 to 2.4 in head at its greatest depth; two very small nostrils in front of each eye, the anterior one in a low tube and the other a simple opening; a rather indistinct notch above angle of opercle, which is minutely serrated, as is the inferior edge; preopercle unarmed; least depth of caudal peduncle less than half the length of snout, 3.9 to 4.5 in head; head scaled on cheek

and on upper angles of opercle and preopercle; trunk and caudal peduncle completely covered with minute cycloid scales; caudal fin scaly, the other fins naked; middle dorsal spines highest, the last 2 to 2.2 in head; last anal spine highest, about as long as snout, 1.8 to 2 in head; the soft portions of dorsal and anal slightly angular, the former slightly the higher and 1.5 to 1.7 in head; the moderately forked caudal shorter than head, 3.6 to 4.3 in length of body; pectoral about as long as from tip of snout to posterior margin of pupil, 1.27 to 1.37 in head, or 4.1 to 4.4 in length; ventral extends to base of first anal spine, 1.5 to 1.6 in head; last ray about as long as outer spine, which is 1.3 to 1.4 times inner one.

Alcoholic specimens mottled with brownish; a broad blackish band extends from origin of dorsal through eye to mouth, uniting with the other on opposite side at both ends, inclosing a paler longitudinal area on top of head; breast blackish, this color extending to above base of pectoral and to outer spine and ray of ventral fin; a large blackish blotch of circular or irregular shape on lateral line below posterior spines and anterior rays of dorsal; dorsal, anal, and caudal yellowish white, or dorsal spines brownish yellow anteriorly, or first dorsal spine may be blackish; a dusky line on both sides of each anal spine; first pectoral ray blackish, the rest of the fin very pale yellowish.

We have 4 specimens, 138 to 174.5 millimeters in length; one from Elefante Island, Marinduque Province, two from Tagapula Island, Samar Province, and one from Cebu, Cebu.

Known heretofore only from the type specimen described by Evermann and Seale from Bacon, Sorsogon.

This species is distinguished at a glance from *Lo vulpinus* (Schlegel and Müller) by the presence of the large blackish blotch far back on lateral line.

LO VULPINUS (Schlegel and Müller). Plate 6.

Amphacanthus vulpinus SCHLEGEL and MÜLLER, Verh. Nat. Gesch. Ned., Leiden 2 (1844) 12; SCHLEGEL, Bijdr. Dierk. 1[e] (1852) 38, fig. 1; WEBER, Fische Siboga Exp. (1913) 330.

Teuthis vulpinus GÜNTHER, Cat. Fishes 3 (1861) 324.

Teuthis vulpina GÜNTHER, Fische der Südsee 1 (1873) 91.

Lo vulpinus SEALE, Occ. Papers Bishop Mus. 4 (1906) 71, fig. 19; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 361.

Siganus vulpinus FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 59.

The oblong compressed body moderately elongate, its depth 2.2 to 2.4 in length, dorsal and ventral outlines nearly parallel

from nuchal region to first dorsal ray; head produced anteriorly, much longer than deep, its length 3.1 to 3.3 times in that of head and body together, its upper profile concave, rising above eye in a thin trenchant ridge; interorbital space nearly flat and with a conspicuous protuberance on front and upper angle of eye, its width 3.3 to 3.7 in head; diameter of the rounded eye 3.5 to 3.9 in head or nearly twice in the long produced snout, which is 1.8 to 1.9 in length of head; maxillary shorter than eye, 4.6 to 5.2 times in head; preorbital 1.2 to 1.6 in snout or 2.3 to 2.9 in head; two very small nostrils in front of each eye, the anterior one in a low fleshy tube and the other a simple rounded opening closer to the former than to anterior edge of eye; a very shallow notch above angle of preopercle, which is finely serrated as is also its inferior margin; opercle unarmed behind; least depth of caudal peduncle 3.9 to 4.1 in head.

Head naked except on cheek, and on uppermost portions of opercle and preopercle; trunk and caudal peduncle completely covered with tiny scales; all the fins naked except caudal, upon which minute scales extend for half its length; middle dorsal spines equal to or a little higher than the last one, which is 1.8 to 2 in head and nearly as long as snout; last anal spine highest, higher than last dorsal spine, 1.7 to 1.9 in head; soft dorsal and anal pointed behind, the former slightly higher, 1.6 to 1.8 in head; caudal fin moderately forked and shorter than head, 1.1 to 1.4 in head and 3.6 to 4.4 in length, its lobes equally produced; pectoral a trifle shorter than caudal fin, 1.2 to 1.4 in head; ventral fin reaches origin of anal, its outer spine much longer than the inner one and contained 1.5 to 1.6 in head.

Alcoholic specimens more or less whitish, yellowish, or mottled brown, to largely blackish brown, upper part usually darker, sometimes umber or blackish; posterior third usually but not always paler; from origin of dorsal a broad black or dark brown band extends diagonally downward and forward over eye to end of snout, including upper and lower lips, joining its fellow on nape and chin, and leaving a paler median stripe from nape to base of upper lip; behind this band is a broader diagonal pearly white or brownish band, profusely sprinkled with reddish brown dots, covering the remainder of head below and behind eye, and extending across anterior extremity of breast; breast black to dark brown, the color extending above base of pectoral behind and into gill opening, and posteriorly to ventrals; dorsal, anal, and caudal vary from pale yellowish white to brown; upper

ray of pectoral brown to blackish, the rest of the fin whitish to brown; ventral spines blackish or brown, the rays brownish.

The Bureau of Science collection has nine specimens, from 149 to 180 millimeters in length, from the following localities: Calapan and Bulalacao Bay, Mindoro; Sibuyan; Bennett Island, Masbate; and Zamboanga, Mindanao. The only previous record from the Philippines is that by Fowler and Bean, who had four specimens from Zamboanga.

In life this is a fish of great beauty and stateliness. A specimen kept for a year or two in the Bureau of Science aquarium was one of the most attractive on exhibition. The prevailing color was deep orange on the posterior half, the caudal and the vertical fins; the anterior half was banded as described above, but the colors were lustrous and in strong contrast.

This very handsome siganid has been recorded from Celebes, Ternate, Amboina, New Guinea, and the Solomon and Pelew Islands. According to Weber, it does not range west of Celebes. As it is unknown in Polynesia, it seems to have a restricted range.

SUMMARY OF THE PHILIPPINE SIGANIDÆ

SIGANIDÆ (TEUTHIDIDÆ)

1. Genus TEUTHIS Linnæus

1. **fuscescens** (Houttuyn).
2. **concatenata** (Cuvier and Valenciennes).
3. **corallina** (Cuvier and Valenciennes).
4. **rostrata** (Cuvier and Valenciennes).
5. **hexagonata** (Bleeker).
6. **oramin** (Bloch and Schneider).
7. **sutor** (Cuvier and Valenciennes).
8. **puella** (Schlegel).
9. **virgata** (Cuvier and Valenciennes).
10. **doliata** (Cuvier).
11. **tetrazona** (Bleeker).
12. **javus** Linnæus.
13. **lineata** (Cuvier and Valenciennes).
14. **striolata** Günther.
15. **vermiculata** (Cuvier and Valenciennes).

2. Genus LO Seale

16. **unimaculatus** Evermann and Seale.
17. **vulpinus** (Schlegel and Müller).

ILLUSTRATIONS

PLATE 1

FIG. 1. *Teuthis fuscescens* (Houttuyn). (Drawing by A. L. Canlas.)
2. *Teuthis corallina* (Cuvier and Valenciennes). (Drawing by José L. Nievera.)
3. *Teuthis rostrata* (Cuvier and Valenciennes). (Drawing by Pablo Bravo.)

PLATE 2

[Drawings by Pablo Bravo.]

FIG. 1. *Teuthis hexagonata* (Bleeker).
2. *Teuthis sutor* (Cuvier and Valenciennes).
3. *Teuthis doliata* (Cuvier).

PLATE 3

[Drawings by A. L. Canlas.]

FIG. 1. *Teuthis vermiculata* (Cuvier and Valenciennes).
2. *Lo unimaculatus* Evermann and Seale.

PLATE 4

[Drawings by A. L. Canlas.]

FIG. 1. *Teuthis concatenata* (Cuvier and Valenciennes).
2. *Teuthis puella* (Schlegel).
3. *Teuthis virgata* (Cuvier and Valenciennes).

PLATE 5

[Drawings by A. L. Canlas.]

FIG. 1. *Teuthis oramin* (Bloch and Schneider).
2. *Teuthis striolata* Günther.
3. *Teuthis javus* Linnæus.

PLATE 6

Lo vulpinus (Schlegel and Müller.) Drawing by A. L. Canlas.

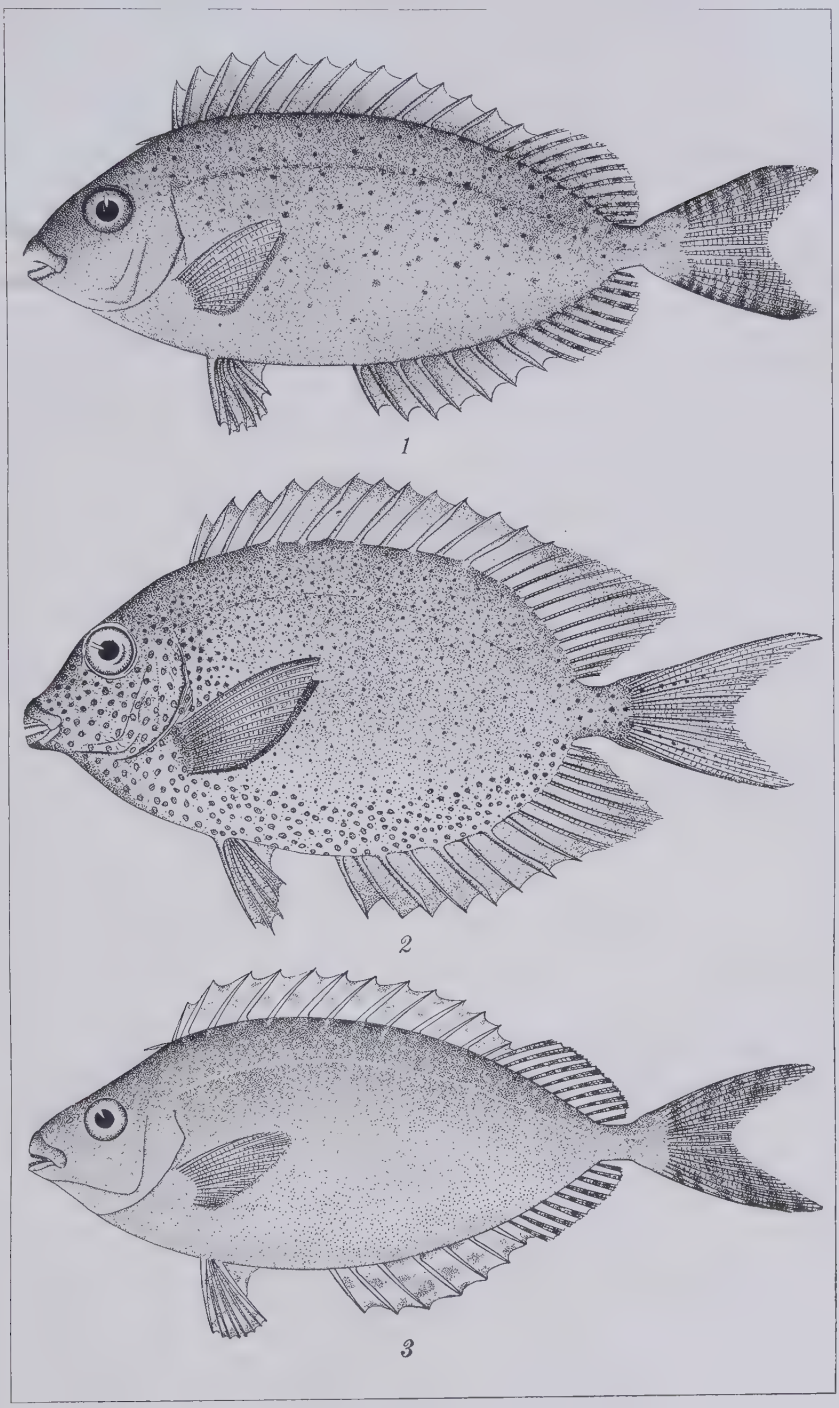


PLATE 1.

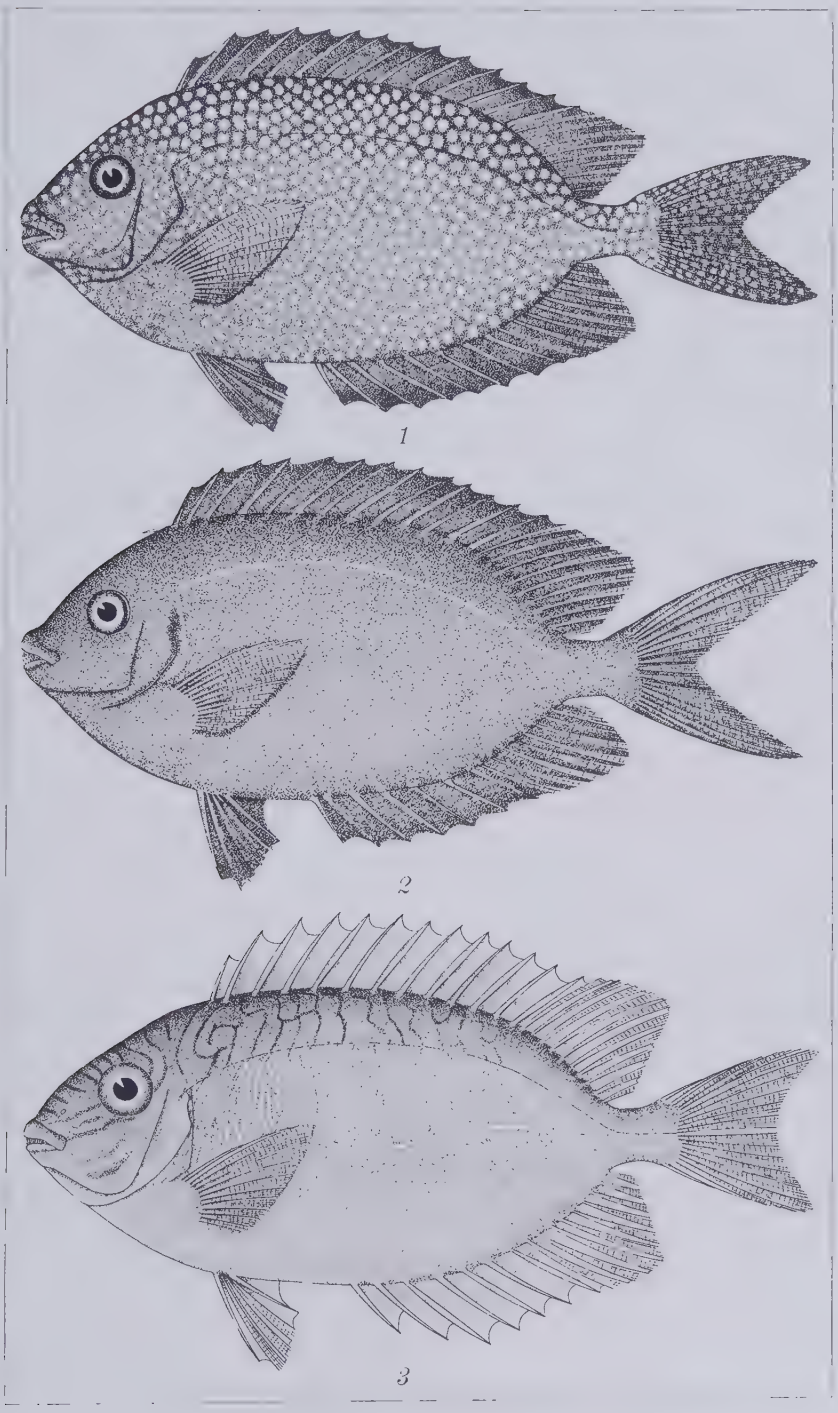


PLATE 2.

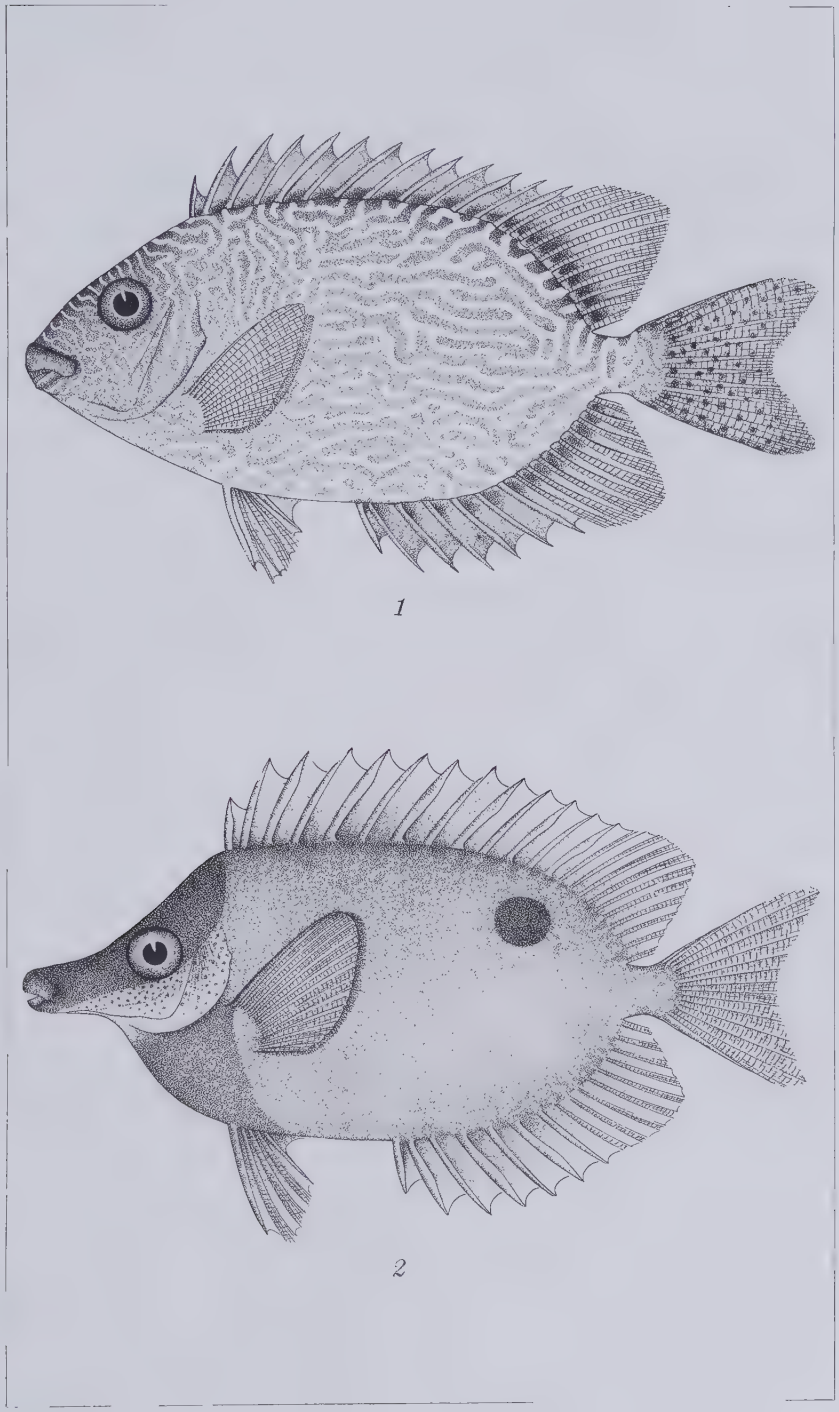
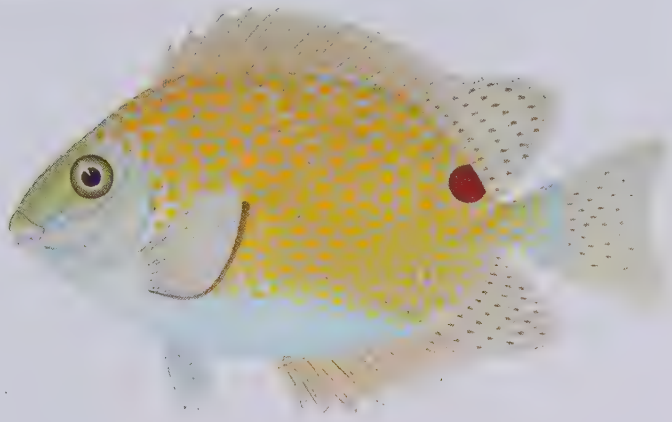


PLATE 3.



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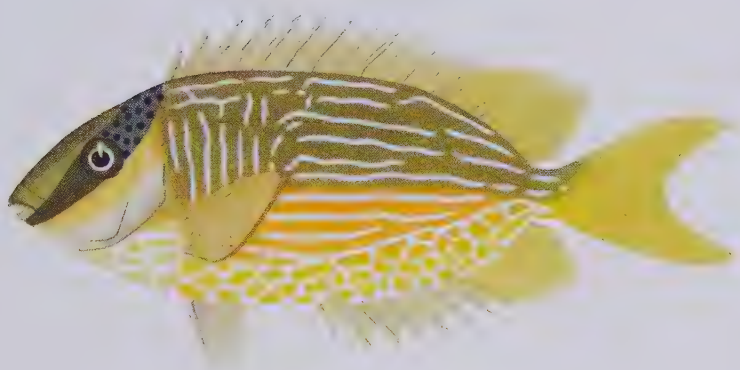

2

3

PLATE 4.

PLATE 5.

PLATE 6. LO VULPINUS (SCHLEGEL AND MÜLLER).

STEM AND LEAF STRUCTURE OF TINOSPORA RUMPHII BOERLAGE AND TINOSPORA RETICULATA MIERS

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SEVEN PLATES

Much has been written and published in various works concerning the anatomical features of the Menispermaceæ. The subject, however, has by no means been exhausted, for the anatomical structure of this family in general is very characteristic in every species. Any further anatomical investigation, therefore, concerning the stems and leaves of this important family will be of considerable interest, notwithstanding the fact that valuable anatomical studies on a number of its species have been made in the past. Since *Tinospora rumphii* Boerlage and *T. reticulata* Miers afford excellent material for anatomical investigation, and because of the medicinal property reputed by the Filipinos to be possessed by one of the two species, which has a bitter taste, the writer undertook this piece of work in order to find the basis for differentiating the two plants.

Tinospora rumphii Boerlage and *T. reticulata* Miers are both commonly known as *makabuhay,* and sometimes the latter is called *makabuhay lalaki.* They are dicœcious vines with perennial stems covered with prominent tubercles, twining around tall trees and sending out roots many meters in length which descend like cords to the ground. They are widely distributed throughout the Philippines and *T. rumphii* Boerlage is sometimes cultivated because of its very bitter characteristic. According to Merrill,(5) *T. rumphii* was perhaps introduced from Malaya, while *T. reticulata* is endemic.

Merrill(6) describes *Tinospora reticulata* Miers as a plant that possesses a very bitter characteristic. On the other hand, in a later work(7) he states that—

> The name *makabuhay* is universally applied in the Philippines to the two forms of *Tinospora,* but properly to the one with broad, deeply cordate leaves that has a very bitter principle in its stems.

which is the form characterized by Boerlage as *Tinospora rumphii*. Besides, Merrill, in a still later publication,(8) gives the same name, *T. rumphii*, to the plant exhibiting the same characteristic.

In India the species *Tinospora cordifolia* Miers is used and classified as a standard drug in the Indian Pharmacopœia. This plant is frequently substituted by *Tinospora crispa* Miers and by allied species, also found in the Indo-Malayan region. In view of the similarity between *T. crispa* and the bitter makabuhay from the Philippines, Tavera,(10) in describing the latter, applied the name *Tinospora crispa* Miers, which plant the writer believes is not found in the Philippines.

The bitter makabuhay has, on account of its economic value, long occupied a prominent place in chemical research, especially among plant chemists and pharmaceutical chemists, to whom the question is naturally an all-important one.

Bacon(1) and Feliciano,(2) working on the chemical composition of the bitter makabuhay, both reported their results under the name *Tinospora reticulata* Miers. Marañon,(4) on the other hand, recently conducted a very critical chemical investigation on the same bitter makabuhay and successfully isolated its bitter principle, and reported his results under *Tinospora rumphii* Boerlage.

Solereder,(9) in reviewing the work done on the anatomical features of the Menispermaceæ, indicates that in all the members of this family are observed the presence of broad primary medullary rays which separate the vascular bundles of the axis from one another; the undulated composite and continuous sclerenchymatous ring in the pericycle; the elongated secretory cells in the axis and in the petiole in certain members of the order; and the small crystals of calcium oxalate which are sometimes large, solitary, or clustered. Some of the prominent workers cited by him are Nageli, De Bary, Vesque, Schenck, Volkens, Solereder, Haberlandt, and others. Unfortunately, most of their publications are not available.

MATERIAL AND METHODS

Tinospora rumphii Boerlage and *Tinospora reticulata* Miers, the plants that furnished the materials for this investigation, were collected from Antipolo, Rizal Province, Luzon, during the summer of 1925, and planted in the botanical garden in the University of the Philippines. Additional material for the study

of the bitter makabuhay (*Tinospora rumphii* Boerlage) was bought from a retail store in Binondo, Manila.

These two species of makabuhay were grown in the botanical garden side by side, and during the preparation of this paper the external morphological characters of the stems were carefully observed, and those of one species were compared with those of the other. The taste of the sap of their stems and leaves was tested.

Several cross and median longitudinal sections, from 20 to 35 microns thick, were used. Some of the sections were stained with safranin and contrasted with Delafield hæmatoxylin and mounted in balsam, while the other sections were simply examined and mounted in water and in dilute glycerine. For the examination of the individual shape and characteristics of the cells, Schulze's maceration process, as indicated by Greenish,(3) was employed.

TINOSPORA RUMPHII BOERLAGE

THE STEM

The young fresh stems of *Tinospora rumphii* Boerlage are light green, succulent, smooth, and sometimes with minute elongated elevations which correspond to young lenticels arranged parallel to the axis. They bear broadly ovate and deeply cordate, alternate leaves (Plate 1, fig. 1). When the young stems are cut, they exude a clear, mucilaginous juice which has a very bitter taste. This bitter characteristic is also observed when the leaves are crushed between the fingers.

The adult stems, however, have a dark green or greenish brown color and succulent bark covered with numerous and prominent protuberances, at the tip of which the lenticels are found. They are invested with a very thin cork which peels off in flakes, and they are leafless. When bent they are more or less flexible, and when cut they exude abundant, somewhat milky or turbid, mucilaginous juice which has a very bitter taste. When dry they shrink very much and the bark separates from the wood and turns dull brown. The odor is not at all peculiar.

The drug of makabuhay sold in the market is always that of *Tinospora rumphii* Boerlage. This adult stem is cut to about 1.5 meters in length and wound up as indicated in Plate 1, fig. 2. It is usually obtained from the store in a more or less fresh condition. This is perhaps due to the fact that the makabuhay stem can stand long keeping without drying. The old stem

bought from the retail store at Binondo, after having been kept for about two months in the laboratory, has shrunk but slightly and sent out a slender root about 1 m long and about 1.2 mm in diameter. When planted, it developed new shoots and leaves.

Structure of the stem.—A thin transverse section from a young stem reveals that it is of the ordinary dicotyledonous type. It is more or less circular in outline and with slightly wavy margin and one or two glandular hairs. These glandular hairs are of multicellular type, uniseriate, and with somewhat rounded terminal cells. The epidermis consists of a single layer of colorless rectangular cells containing usually a large number of monoclinic and prismatic calcium oxalate crystals, as shown in Plate 1, fig. 5. In the surface preparation, these crystals appear as indicated in Plate 2, fig. 7. The cortex is thin and is composed of three or four layers of collenchyma cells and from six to eight layers of parenchyma cells, both containing chloroplastids (Plate 2, fig. 8). Between these cells there are a few young bitter-principle ducts which it is very difficult to distinguish from the parenchyma cells, owing to their close similarity in structure. They can be detected only by the absence of the chloroplastids. The starch sheath is inconspicuous. The pericycle consists of an undulated, continuous sclerenchymatous ring which is composed simply of the arcs of primary, hard bast and parenchyma cell, the latter being in the inner part (Plate 1, figs. 3 and 4). The primary vascular bundles are arranged in the form of a ring and vary in number from ten to fifteen. The wood is composed mostly of one or two spiral and annular vessels and xylem parenchyma. The pith is occupied by parenchyma cells with circular outline.

The structure of an adult stem is more characteristic and complicated. The outline of a transverse section is somewhat circular with one or two prominent projections at the side (Plate 2, fig. 6). These projections correspond to the section of the protuberances or the elevated lenticels. The bark is thick; in the region of the lenticel it is very thick. The outermost part of the cortex is limited by a thin periderm consisting of several layers of flattened cork cells and a few layers of phellogenetic cells. The periderm originates from the tangential division of the subepidermal cells; that is, at first it occurs near the region of the lenticels and then spreads peripherally (Plate 2, fig. 9). In the first division of these cells, the resulting inner daughter cells become the phellogen layer, from which

the cork cells arise. The cork cells are brownish, closely fitted, slightly suberized, and completely flattened, as indicated in Plate 2, fig. 10. When they are isolated by Schulze's maceration process, they exhibit a polygonal outline (Plate 2, fig. 11, *a* and *b*). They measure about 0.056 mm in their longest diameter, and 0.04 mm in their shortest diameter. The phelloderm is not distinct and is poorly developed in other parts of the sections.

The lenticels.—The structure of the lenticels of *Tinospora rumphii* is identical to that of the ordinary dicotyledonous plants, but they are located at the tips of the tuberclelike structures, or protuberances, found on the stems. These protuberances originate and develop from the phellogen layer. They measure about 5 mm in length (Plate 1, figs. 3 and 4, and Plate 2, fig. 6).

The cortical parenchyma.—The cortical parenchyma extends several layers of cells deep and is not limited by a distinct starch sheath. It is not uniform in thickness. In some parts it is very thick on account of the projections in which the lenticels are found. Its average thickness is about half of the diameter of the central cylinder. For convenience the cortex may be divided into, say, two regions; namely, the chlorophyllous region and the nonchlorophyllous region.

The chlorophyllous region.—The chlorophyllous region usually occupies about one-third of the cortex. It is composed of eight or more layers of parenchyma cells containing chloroplastids. These parenchyma cells have thin walls with a circular outline, and those near the phellogen are somewhat tangentially elongated. Between them there are numerous ducts, or bitter-principle sacs, which have the general appearance of ordinary parenchyma cells in cross section. They are easily distinguished from the parenchyma cells, however, because they do not contain chloroplastids, and they are usually larger and surrounded by six or eight slightly flattened parenchyma cells (Plate 2, figs. 10, 13, 14, and 15). They are very numerous in the peripheral side of the chlorophyllous region. A detailed description of their structure and development is given below.

In a cross section of a very old stem there are usually patches of stone cells in the cortex near the phellogen layer. These stone cells are sometimes found in an extended layer forming a sort of ring around the peripheral part of the cortex. They are somewhat cubical and their walls are yellowish, thick, pitted, and lignified to stony hardness. They sometimes contain large,

solitary, rhomboid or monoclinic calcium oxalate crystals, as represented in Plate 2, fig. 12.

The nonchlorophyllous region.—The nonchlorophyllous region is thicker and occupies about two-thirds of the entire cortex. It is built up entirely of thin-walled parenchyma cells without chloroplastids and between them are a few bitter-principle sacs. These parenchyma cells have very thin walls, are circular in cross section, and usually filled with abundant, small, ovoid or somewhat rounded starch grains. The cells toward the inner part, however, are sometimes radially elongated, more or less rectangular in form, and arranged in rows radiating from the crescent-shaped band of sclerenchymatous cells belonging to every vascular bundle (Plate 3, fig. 19). This arrangement of the inner parenchyma cells is especially evident in the cross section of a very old stem. Plate 3, fig. 20, is taken from a region between the cortical parenchyma and the sclerenchyma of the pericycle which shows the rectangular shape of some of the inner parenchyma cells of the nonchlorophyllous region. Adjoining the sclerenchyma band there is a layer of cells which correspond to the starch sheath, containing large, solitary, prismatic or monoclinic calcium oxalate crystals. Plate 3, fig. 21, shows a longitudinal section corresponding to fig. 20 on the same plate, cited above. It shows a row of cells, also containing calcium oxalate crystals. These rows of cells can be isolated by means of Schulze's maceration process and, when isolated, they appear as crystal fibers measuring about 0.27 mm in length (Plate 3, fig. 22).

The bitter-principle sacs.—In the cortical parenchyma of the stem, petiole, and midrib, the writer has observed some structures other than parenchyma cells which, in cross section, have the general appearance of parenchyma cells, except that they are larger; and in longitudinal section they appear as elongated vessels. These structures can be called bitter-principle sacs, owing to the fact that they possess a more or less clear or opaque mucilaginous sap containing bitter principles. According to Solereder,(9) similar structures called secretory sacs were observed by Bailon in *Anamirta* and they were erroneously described by Blottiere as "Cannaux laticiferes." Solereder indicates that these secretory sacs may occur in the pith as well

as in the cortex and that they have so far been observed by him, by Blottiere, and by Volkens in the following species:

Anamirta cocculus Wight and Arnold.
Burasaia madagascarensis de Candolle.
Cissampelos caapeba Linnæus.
Cocculus leaeba de Candolle.
Diploclisia macrocarpa Miers.
Jateorrhiza palmata Miers.
Limacia velutina Miers.
Tinospora cordifolia Miers.

The bitter-principle sacs of *Tinospora rumphii,* unlike the secretory sacs described above, occur only in the cortical region and are especially numerous in the peripheral part of the cortical parenchyma of the adult stem where the chloroplastids are abundant. They do not occur in the pith or the pith rays. A critical investigation as to their origin and development reveals that they arise and develop from the gradual and complete destruction of the cross walls of a row of parenchyma cells, as shown in Plate 2, figs. 15, 16, and 17. They possess all the characteristics of the articulated latex tubes, except that they are not greatly elongated and that they neither anastomose nor branch. They are found as independent tubes of various lengths, scattered in the cortical region of stem, petiole, and midrib. More significant evidence that they originate by the complete disappearance of the cross walls of a row of parenchyma cells is observed in the preparation made from the bark of a young and an adult stem macerated with a 2 per cent solution of potassium hydroxide. Some of the sacs are more or less isolated and their contents appear in coagulated form and are of a grayish color. Different stages of their formation are observed. A row of four or five cells may be separated and the cross walls of some of them be partially or completely dissolved as shown in Plate 2, figs. 15, 16, and 17. In the older stages of the sacs the remains of the transverse walls of the original cells cannot in most cases be traced (Plate 3, fig. 18, *a* to *c*). A microchemical test of the content of the bitter-principle sacs revealed that it has a reducing effect on Fehling's solution.

The pericycle is composed of (*a*) the sclerenchymatous crescent-shaped bands of hard bast fibers belonging to the separate vascular bundles and (*b*) parenchyma cells. These crescents of hard bast limit the outer portions of the phloëm and extend around the stem, concentric with the cambium ring (Plate 1,

figs. 3 and 4; Plate 2, figs. 6 and 8; Plate 3, figs. 19, 20, and 21). They consist of small thick-walled and lignified cells with polygonal outline in cross section and greatly elongated in longitudinal section. Their walls are slightly pitted, unbranched, and somewhat tapering at both ends (Plate 3, fig. 28). They measure about 0.02 mm in diameter and from 0.7 to 1.4 mm in length. The parenchyma cells between the crescentic bands of sclerenchymatous elements usually become sclerosed. Their walls are greatly thickened, lignified into stony hardness, and frequently with the inclusion of a large solitary monoclinic or rhomboid calcium oxalate crystal. In view of the formation of these stone cells, the crescents of sclerenchyma fibers are united and thus the pericycle appears as an undulated composite and continuous sclerenchymatous ring in structure in the old stem, which is indicated by Solereder(9) as a general characteristic of menispermaceous plants.

The vascular bundles are separated from one another by broad, primary medullary rays, and they stand out distinctly even to the naked eye in a transverse section of the stem. The number of vascular bundles in an adult stem varies from 16 to 20, new bundles having been produced between the primary ones. The phloëm of the vascular bundles is a narrow zone within the pericycle. In the outer portion it is limited by large parenchyma cells with thin and delicate walls, which are usually broken or torn out in sectioning, and in the inner side it is separated from the xylem region by a cambium which consists of a layer of thin-walled, delicate, tubular cells. The phloëm is composed of sieve tubes, companion cells, and phloëm parenchyma. The phloëm cells toward the periphery are usually flattened or shriveled, forming a dark zone in the form of an arc, while those toward the cambial portion are somewhat polygonal and rectangular in outline, and frequently arranged in irregular rows.

The xylem region is composed chiefly of xylem, metaxylem, and protoxylem vessels, wood fibers, and wood parenchyma (Plate 3, figs. 19, 23, and 24). In the lateral part it is limited by a row of cells which are somewhat radially elongated, and sometimes contains some calcium oxalate crystals. The vessels are characterized by their large circular lumina, which measure from 0.15 to 0.38 mm in diameter, and are visible to the naked eye. They are usually filled with tyloses and possess thick walls with perforations. They have bordered pits, even in places

where they are found in contact with parenchyma cells. Plate 3, fig. 3, is a detailed representation of a portion of the cross section of a vascular bundle showing a large vessel filled with tyloses and surrounded by wood parenchyma. In a longitudinal section cut through the vascular bundle, these vessels appear as continuous tubes made up of rows of cells the cross walls of which have been dissolved (Plate 3, fig. 24). When macerated with nitric acid and potassium chlorate, the vessel cells exhibit a diversity of forms. They vary from a cylindrical shape, as shown in Plate 3, fig. 27, *a* and *b*, and Plate 4, fig. 30, to a barrellike or beakerlike outline with tangentially elongated pits. They measure from 0.072 to 0.26 mm in diameter and from 0.2 to 0.44 mm in length. The metaxylem and protoxylem vessels have smaller cavities and their walls possess either pitted, annular, or spiral thickening. The wood fibers or libriform fibers are thick-walled, lignified, and greatly elongated cells with simple pits. Both ends are somewhat pointed and sometimes irregularly convoluted, or wavy. They measure from 0.480 to 0.555 mm in length. The xylem parenchyma cells are short and have thin walls; they also possess simple perforations and their two ends are blunt and not tapering.

The medullary rays in cross section appear uniform in structure. They are made up of several rows of thin-walled, pitted, and radially elongated parenchyma cells. The ray cells are in most cases filled with a considerable number of starch grains. In the radial section they appear rectangular and sometimes square, with large simple pits. Plate 4, fig. 32, represents a group of ray cells isolated by Schulze's maceration process.

The central pith of the stem in cross section is somewhat circular in shape and about 3 mm in diameter. It is composed principally of thin-walled parenchyma cells with polygonal or circular outline. In a very old stem the walls of some of the parenchyma cells, however, become greatly thickened, lignified, and perforated by numerous, usually branched, pit canals of circular appearance in transverse section. These lignified cells appear in groups or patches in the pith region. Their cavities are sometimes greatly reduced when the walls become very thick and sometimes contain inclusion of large solitary rhomboid or circular appearance in transverse section. These lignified cells of a transverse section of the pith of an older stem, and fig. 26, on the same plate, represents a corresponding longitudinal section taken from the same stem. The walls of the lignified

parenchyma cells in these figures are not greatly thickened. When these cells are isolated by maceration, they exhibit a more or less rectangular shape or a beakerlike outline (Plate 4, fig. 33, *a* to *c*). Plate 4, fig. 34, is prepared from stone cells from the pith of a very old stem, isolated by maceration. Their walls are greatly thickened, striated, and with simple or branched perforations. Each of the two stone cells shown on Plate 4, fig. 35, contains a large solitary crystal in the cavity.

The starch grain.—The cells of the inner part of the cortical parenchyma, the medullary rays, and the pith are usually supplied with abundant, small, ovoid, or somewhat rounded starch grains which measure from 0.006 to 0.025 mm in diameter. These starch grains do not possess a distinct hilum and are not prominently striated.

THE LEAF

The full-grown leaves are from 8 to 16 cm long and from 10 to 14 cm wide. They are broadly ovate in outline, long petiolate, thin, glabrous, dark green and shining on the upper surface, and light green on the lower surface. The base is deeply cordate and sometimes nearly truncate. The margin is entire and the apex acuminate. At the base there are five nerves belonging to the first order (Plate 1, fig. 1). The petioles are from 5.5 to 10.5 cm long, and about 2 mm in diameter, nearly cylindric or somewhat angular, with a narrow and slightly elevated ridge in the upper part. When the fresh leaves are crushed between the fingers, the odor is not characteristic, but the taste is very bitter.

The structure of the leaf.—The leaf structure of *Tinospora rumphii* Boerlage in transverse section is bifacial. The mesophyll is rather uniform in thickness and measures about 0.165 mm. The upper epidermis is composed of a single layer of tangentially elongated, rectangular, and sometimes nearly square cells with thick and cutinized outer cell walls. These cells in most cases contain monoclinic or prismatic calcium oxalate crystals (Plate 4, fig. 36). The lower epidermis also consists of a layer of cells, of the same shape and with some calcium oxalate crystal inclusion, but with very much thinner and less-cutinized outer cell walls. The palisade chlorenchyma occupies about one-fourth of the section, and consists of a single row of perpendicularly elongated or tubular cells, about 0.05 mm in length and 0.01 mm in diameter, and formed just below the upper epidermis. The spongy cholorenchyma is made up of irregularly

shaped parenchyma cells of various sizes and with few chloroplastids. It is about twice as thick as the palisade region and measures about 0.108 mm thick. Along this part of the mesophyll, there are at regular intervals remarkably large intercellular spaces of a circular or somewhat horizontally elongated outline in cross section (Plate 4, fig. 36). These air spaces measure from 0.120 to 0.150 mm in diameter and communicate with the smaller intercellular spaces between the spongy chlorenchyma cells. The epidermal outgrowths consist chiefly of multicellular, uniseriate grandular hairs of from two to three cells and are observed only in the lower epidermis. The capitate part of these hairs is nearly rounded in shape (Plate 4, fig. 38).

In the surface preparations, the epidermal cells appear polygonal in outline with from five to seven straight, thick walls. They are 0.025 to 0.043 mm in their longest diameter and from 0.018 to 0.032 mm in their shortest diameter. The calcium oxalate crystals observed in the cross section are more evident and better displayed in this preparation, as indicated in Plate 4, fig. 37. The lower epidermal cells are also polygonal in outline and are richly supplied with calcium oxalate crystals, but they are smaller and their walls are thinner and more or less wavy (Plate 4, fig. 38). They measure from 0.036 to 0.101 mm in their longest diameter and from 0.018 to 0.036 mm in their shortest diameter. The stomata are confined in the lower surface of the leaf. They occur in patches in the area between the veinules. Their sizes are not uniform and they vary from 0.025 to 0.032 mm in length and from 0.021 to 0.027 mm in width. They are surrounded by from three to six neighboring cells. One of the neighboring cells is invariably smaller than the others, and this smallest neighboring cell is usually applied vertically to the length of the guard cells. The glandular hairs are better observed in this surface preparation than in the cross section.

The midrib is slightly convex above and strongly convex below. The outline in the lower part is irregularly wavy (Plate 4, fig. 36). The ventral epidermis as well as the dorsal consists of a single layer of cells, rectangular or nearly square in outline. The outer cell walls of the upper epidermis are comparatively thicker and more cutinized than are those of the lower epidermis. Some of those of the lower epidermis are papillose in nature; that is, they exhibit slight outgrowths or projections. The collenchyma cells are present in two distinct regions, above and below the midrib, just inside the epidermis. In the inner

part of these cells toward the stele is a region of cortical parenchyma consisting of thin-walled cells. Here and there, in this parenchyma region, there are some bitter-principle sacs. The meristele is somewhat fan-shaped or nearly circular. The upper part is bounded by a group of small, thin-walled parenchyma cells, which are polygonal in outline. The xylem is composed of large vessels, from 0.025 to 0.043 mm in diameter, and xylem parenchyma. Below the xylem is the phloëm region, which is made up of the same type of cells as is the phloëm of the stem. The phloëm is usually traversed by a row of parenchyma cells or pith-ray cells. The outer part of the phloëm consists of a few layers of parenchyma cells which are limited by two or three layers of colorless, slightly lignified sclerenchyma fibers, forming a sort of arc in the lower part of the vascular bundle.

The petiole.—The structure of the petiole is very similar to that of the stem. In cross section it appears as a somewhat circular and wavy outline, and contains a circular system of isolated vascular bundles, which vary from six to eight in number. The epidermal cells are more or less isodiametric in nature and some contain calcium oxalate crystals. The cortex is thick, consisting of two or three layers of collenchyma cells, and a few layers of chlorenchyma. Between these cells are also some bitter-principle ducts. The starch sheath is not distinct. The pericycle, like that of the stem, consists of a continuous, undulate sclerenchyma band. Plate 4, fig. 39, is a diagrammatic representation of a cross section of a petiole traced under a 48-millimeter objective with the aid of a camera lucida. The vascular bundles are separated by the medullary rays and the pith, which is nearly circular in outline, is large.

TINOSPORA RETICULATA MIERS

THE STEM

The young, fresh stems of *Tinospora reticulata* Miers have almost the same general appearance as have those of *Tinospora rumphii* Boerlage. The former differ, however, from the latter in that the leaves have a truncate or sometimes slightly cordate base (Plate 5, fig. 40, *a* and *b*). Moreover, when these young stems are cut, they exude a clear, mucilaginous, and tasteless or very slightly sweetish juice.

The adult stems of *Tinospora reticulata,* on the other hand, are rather different from the stems of *Tinospora rumphii* in various features. In the first place, the stems of the former

have fewer and less-prominent protuberances than are observed in the latter. In the second place, the stems of *Tinospora reticulata* vary from straw or brownish yellow to greenish sepia color, with whitish or grayish lichen patches in some places, while those of *T. rumphii* are usually dark green or brownish green. Both types of stems, however, are invested with very thin cork which peels off in flakes, and they are leafless. When bent they are somewhat flexible. Perhaps the most significant difference between the two species lies in the relative amount and taste of their sap. When the stems of *T. reticulata* are cut, they exude a scanty, clear, and very slightly bitter, mucilaginous sap, while those of *T. rumphii,* when cut, as indicated above, exude abundant mucilaginous sap, of a somewhat milky or turbid appearance and with a very bitter taste. When dry the stems of *T. reticulata* shrink but slightly and the bark is more or less separated from the wood. Their color remains almost the same, while the odor is also not at all characteristic.

Structure of the stem.—The structure of a transverse section of a young stem of *Tinospora reticulata* is practically identical with that of the young stem of *T. rumphii.* The only difference is that in *T. reticulata* the cortical parenchyma is relatively thinner and does not contain so many bitter-principle sacs. The glandular hairs are apparently less numerous and sometimes are not observed in the cross sections.

The structure of the adult stem is just as complicated and interesting as is that of the species *T. rumphii* (Plate 5, fig. 41). The outline of a transverse section is also circular with one or two slight projections due to the elevated lenticels. The bark, however, is very much thinner than that of *T. rumphii* and is about one-fifth of the diameter of the central cylinder. Plate 6, fig. 43, is a portion of the cortical parenchyma showing (1) the periderm, consisting of slightly suberized epidermal and subepidermal cells, several layers of flattened cork cells (see also Plate 6, fig. 44, *a* and *b*), a few layers of phellogenetic cells, and phellogen layer; (2) the calcium oxalate crystal ring which is made up of a layer of cells interior to the phellogen region containing large, solitary or small-clustered monoclinic, prismatic or rhomboid calcium oxalate crystals (see also Plate 6, fig. 45); (3) the patches of stone cells found scattered in the peripheral part of the cortical outside of the chlorophyllous region, which are also observed in the case of *T. rumphii;* (4) the chlorophyllous region which has an almost uniform structure consisting simply of small thin-walled, isodiametric

parenchyma cells containing chloroplastids and one inconspicuous bitter-principle sac; and (5) a portion of the nonchlorophyllous region made up of large parenchyma cells containing some small ovoid or oblong ovoid starch grains. The inner layers of cells of this region, like those of the corresponding region in *T. rumphii*, are usually arranged in rows and radiating from the sclerenchyma bands; the only difference is that the parenchyma between these sclerenchyma bands becomes sclerosed earlier than does that of *T. rumphii*. Plate 6, fig. 52, represents a portion of the parenchyma cells between the sclerenchyma bands corresponding to two vascular bundles, showing a group of cells becoming lignified with some large calcium oxalate inclusions.

The lenticels.—The structure of the lenticels of the stem of *T. reticulata* is almost identical to that of *T. rumphii*, but the lenticels of the former are not greatly elevated, as are those of the latter (Plate 5, figs. 40*e* and 41).

The bitter-principle sacs observed in the stems of *T. rumphii* are also found in a very old stem of *T. reticulata*, but they are comparatively fewer in number and are not usually conspicuous in cross section or in the longitudinal section of the stem (Plate 6, figs. 43 and 47). This finding is corroborated when the sap of the old stem is tasted, which is slightly bitter. These bitter-principle sacs found in *Tinospora reticulata* seem to develop only in the older stems and are not found in the leaves and the young stems. They originate and develop in the same way as do those of *T. rumphii*. In the preparations macerated with potassium hydroxide they appear as greatly elongated tubes containing a greenish, somewhat homogenous content, with large globules, oily in appearance. They simulate the ordinary unbranched laticiferous vessels (Plate 6, figs. 46 and 48). Microchemical test proves that the content of these sacs has only a very slight reducing effect on Fehling's solution.

The structure of the pericycle of *T. reticulata* is practically the same as that of *T. rumphii*. In Plate 6, fig. 49, is seen a portion of the transverse section of the pericycle showing the characteristic layer of cells containing solitary, large calcium oxalate crystals which are found limiting the outer part of the lignified, thick-walled sclerenchyma band. Plate 6, fig. 46, shows a portion of a longitudinal section corresponding to the region shown in fig. 49, and fig. 51 shows a crystal fiber isolated

by Schulze's maceration process from the outer part of a sclerenchyma band.

The vascular bundles of *T. reticulata* are about fourteen in number and they are characterized and distributed in the same way as are those of *T. rumphii.* The only, slight difference observed is that the lateral parts are limited by a row of cells usually containing prismatic or monoclinic prismatic crystals of calcium oxalate, as indicated in Plate 6, fig. 53. The vessels, the phloëm cells, wood fibers, and wood parenchyma have practically the same characteristics as have those of *T. rumphii* (Plate 6, figs. 53 and 54, *b* to *d;* and Plate 7, figs. 56, *a* to *c,* and 57).

The pith rays and the pith of *T. reticulata* are characterized by and composed of the same type of cells as are the pith rays and pith of the species *T. rumphii.* The lignification of some of the pith cells in the stems of *T. reticulata,* however, usually takes place earlier than in the stems of *T. rumphii.* Plate 7, figs. 60 and 61, shows cross section and longitudinal sections cut through the pith of an adult stem showing the characteristics of the lignified cell. When these pith stone cells are isolated by maceration they appear as shown in Plate 7, fig. 59, *a* to *b.* In Plate 7, fig. 58, *a* to *d,* are shown four isolated lignified cells from the pith of a younger stem showing the same characteristics as those observed in *T. rumphii* during the early stage of the lignification.

THE LEAF

The full-grown leaves of *T. reticulata* Miers measure from 10 to 13.5 cm long and from 8.5 to 10.5 cm wide. They are ovate in outline, long petiolate, thick, glabrous, somewhat coriaceous, light green and shining on the upper surface, and lighter green on the lower surface. The base is truncate and sometimes slightly cordate (Plate 5, fig. 40, *a* and *b*). The margin is entire and somewhat deflexed, and the apex is acuminate. At the base, as in *T. rumphii,* there are five nerves of the first order. The petioles are from 3.5 to 6.5 cm long, and about 1.8 mm in diameter, nearly cylindric or slightly angular. When the fresh leaves are crushed between the fingers, the odor is not characteristic and the taste is slightly sweetish.

Structure of the leaf.—The leaf structure of *Tinospora reticulata* is very similar to that of *Tinospora rumphii.* The only difference is that the mesophyll of the former is thicker and the

air spaces, which are more or less arranged at regular intervals along the spongy region, are smaller than in the latter (Plate 7, fig. 62). The mesophyll of *T. reticulata* is about 0.18 mm thick and the palisade chlorenchyma 0.05 mm long and 0.01 mm in diameter. The upper and lower epidermis do not contain monoclinic or prismatic calcium oxalate crystals.

In the surface preparation, the upper epidermal cells of *T. reticulata* appear almost like the upper epidermal cells of *T. rumphii,* except that those of the former are larger and usually contain a few calcium oxalate crystals in a more or less raphide form. They measure from 0.054 to 0.072 mm in their longest diameter and from 0.029 to 0.054 mm in their shortest diameter (Plate 7, fig. 63). In the lower epidermis the cells of the former are smaller than are those of the latter and they frequently contain calcium oxalate crystals in the form of raphides (Plate 7, fig. 64). The stomata are almost the same in number, but those of *T. reticulata* are larger. They measure from 0.029 to 0.036 mm in length and from 0.021 to 0.03 mm in diameter. The glandular hairs in *T. reticulata* are usually composed of three cells and are more numerous than in *T. rumphii.*

In *T. rumphii* it is rather difficult to separate the upper epidermis from the mesophyll while the lower epidermis is easily removed. In *T. reticulata,* however, it is just the reverse; the upper epidermis is easily separated from the mesophyll while it is rather difficult to remove the lower epidermis.

The structure of the midrib is very similar to that of *T. rumphii.* The only differences are the presence of some sclerenchymatous cells in the upper and lower parts of the conducting tissue and the absence of the elongated bitter-principle sacs. Moreover, the outline of the lower part of the midrib is more or less uniform in *T. reticulata.*

The petiole.—There are no significant differences between the two plants except that in the cortical region of *T. rumphii* there are some elongated bitter-principle sacs and the number of the vascular bundles in *T. reticulata* varies from 8 to 11. In the arrangement and distribution of the vascular bundles and in the presence of the undulate sclerenchymatous ring of the pericycle, the plants are very similar.

SUMMARY AND CONCLUSIONS

1. Grown under the same conditions, the adult stems of *Tinospora rumphii* Boerlage are distinguished from the stems of

Tinospora reticulata Miers by the facts that those of the former have usually a dark green color, and are succulent and covered with numerous, prominent protuberances at the tip of which the lenticels are found, while the stems of the latter are straw or sepia green in color with fewer protuberances.

2. The stems of the two plants are invested with a very thin cork which peels off in flakes, and both are leafless.

3. The stems of *Tinospora rumphii* possess abundant, somewhat milky or turbid mucilaginous juice with a very bitter taste, while those of *Tinospora reticulata* contain only scanty, clear, and somewhat sweetish or bitterish mucilaginous sap.

4. The periderm in the two plants is very similar. In both it originates and develops from the subepidermis and is made up of several layers of completely flattened, slightly suberized cork cells and phellogenetic cells.

5. The cortical parenchyma of *Tinospora rumphii* is fairly thick and contains abundant bitter-principle sacs, while that of *Tinospora reticulata* is thinner and possesses much fewer bitter-principle sacs. Besides, the outer part of the cortex of the latter contains a layer of cells in the periphery with calcium oxalate inclusions.

6. The bitter-principle sacs originate from the disappearance of the cross walls of a row of cortical parenchyma cells.

7. The pericycle in the two plants is almost identical; in both it shows an undulated composite and usually continuous sclerenchymatous ring.

8. The vascular bundles in both species are separated from one another by broad primary medullary rays and stand out distinctly in transverse section. The xylem vessels are usually filled with tyloses, while the pith rays are filled with starch grains.

9. Some of the cells in the pith of the two stems are observed to become lignified. Those of *Tinospora reticulata,* however, become lignified earlier than do those of *Tinospora rumphii.*

10. The leaves of *Tinospora rumphii* are deeply cordate, while those of *Tinospora reticulata* have a truncate or sometimes slightly cordate base.

11. The leaf structure of *Tinospora rumphii* is somewhat similar to that of *Tinospora reticulata,* but the former has a thinner mesophyll and large rounded air spaces at regular intervals along the spongy region, while the latter has a thicker mesophyll which has smaller air spaces.

12. The upper epidermis and the lower epidermis of *Tinospora rumphii* are very similar to those of *Tinospora reticulata,* but those of the former are richly supplied with monoclinic or prismatic calcium oxalate crystals, while those of the latter contain only a few calcium oxalate crystals in raphides.

13. There are some bitter-principle sacs in the cortical region of the midrib of *Tinospora rumphii* and the sclerenchymatous cells are found only in the lower part of the conducting tissue, while that of *Tinospora reticulata* does not possess bitter-principle sacs at all in the cortical parenchyma, but the sclerenchymatous cells are found in two regions in the upper and lower parts of the conducting tissue.

14. The structure of the petiole in *Tinospora rumphii* is very similar to that in *Tinospora reticulata,* except that the former has some bitter-principle sacs in its cortical parenchyma.

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ILLUSTRATIONS

[All microscopic drawings by the author. The macroscopic drawings for Plates 1 and 5 were made by Macario Ligaya, of the Bureau of Science. The photograph for Plate 1 was made by Jesus Redondo, of the Department of Botany, University of the Philippines.]

PLATE 1. TINOSPORA RUMPHII BOERLAGE

FIG. 1. A habit sketch of a portion of the plant. × ½.
2. A photograph of a portion of an adult stem as sold in the market.
3. A diagrammatic sketch of a transverse section of a young stem; *l*, young lenticel; *scl*, sclerenchyma ring of the pericycle; *vb*, vascular bundles. × 15.
4. A diagrammatic sketch of a transverse section of an older stem showing an elevated lenticel. × 15.
5. A very small portion of the cortex of a young stem with *co*, calcium oxalate crystal deposits, in the epidermal cells. × 105.

PLATE 2. TINOSPORA RUMPHII BOERLAGE

FIG. 6. A diagrammatic drawing of a transverse section of an adult stem; *l*, lenticel; *bs*, bitter-principle sacs; *scl*, sclerenchyma band. × 3.
7. A small portion of the surface view of the epidermal cells of a young stem; *co*, calcium oxalate crystals. × 70.
8. A portion of the cortical parenchyma of a young stem; *g*, glandular hair; *co*, calcium oxalate crystals; *bs*, bitter-principle sac; *scl*, sclerenchyma cells.
9. A very small portion of a transverse section cut through a young stem showing the formation of periderm; *p*, phellogen. × 300.
10. A portion of a transverse section of the cortical parenchyma; *k*, flattened cork cells; *p*, phellogen; *bs*, bitter-principle sacs; *sg*, starch grains. × 158.
11. *a* and *b*, a group of cork cells isolated by maceration. × 200.
12. A portion of the cortical parenchyma near the phellogen region showing *sc*, group of stone cells, and *co*, calcium oxalate crystals. × 158.
13. A transverse section of a bitter-principle sac. × 300.
14. A longitudinal section of a bitter-principle sac. × 200.
15. A longitudinal section of a young bitter-principle sac, showing method of formation. × 353.
16. An isolated young bitter-principle sac, showing the gradual disappearance of cross walls. × 300.
17. Another isolated young bitter-principle sac, showing the disappearance of cross walls. × 300.

PLATE 3. TINOSPORA RUMPHII BOERLAGE

FIG. 18. *a* to *c*, three mature bitter-principle sacs from the cortex of an adult stem. × 300.

19. A transverse section of a vascular bundle; *scl*, sclerenchyma band; *ph*, phloëm; *mv*, metaxylem vessel with tyloses; *wf*, wood fibers; *px*, protoxylem; *pr*, pith ray cells. × 34.

20. A portion of a transverse section of the pericycle and cortex; *sg*, starch grain; *co*, calcium oxalate crystals; *scl*, sclerenchyma cells. × 300.

21. A portion of the longitudinal section cut through the same region as shown in fig. 20; *co*, calcium oxalate crystals; *scl*, sclerenchyma fibers; *sg*, starch grains. × 200.

22. A crystal fiber isolated by maceration from the outer part of the sclerenchyma band. × 200.

23. A portion of the transverse section of a vascular bundle; *co*, calcium oxalate crystal; *mv*, metaxylem vessel; *pr*, pith ray cells. × 158.

24. A longitudinal section through the metaxylem region. × 200.

25. A portion of the transverse section of the pith showing *sc*, some cells becoming lignified. ×94.

26. A longitudinal section corresponding to fig. 25. × 94.

27. *a* and *b*, isolated vessel cells. × 94.

28. A group of sclerenchyma fibers isolated by maceration. × 94.

PLATE 4. TINOSPORA RUMPHII BOERLAGE

FIG. 29. A group of cells isolated by maceration; *a* to *c*, wood fibers; *d* and *f*, xylem parenchyma; *e*, a tracheid with spiral thickening. × 120.

30. An isolated vessel cell. × 120.

31. A group of parenchyma cells from the lateral part of a vascular bundle containing calcium oxalate crystals. × 387.

32. A group of medullary ray cells with simple pits. × 387.

33. *a* to *e*, a group of isolated lignified parenchyma cells from the pith of a young stem. × 120.

34. A group of stone cells from the pith of an adult stem. × 120.

35. A group of stone cells from the pith of an adult stem containing calcium oxalate crystals. × 456.

36. A transverse section cut through the midrib; *col*, collenchyma cells; *scl*, sclerenchyma band; *bs*, bitter-principle sacs; *as*, air spaces. × 90.

37. A surface section of the upper epidermis; *co*, calcium oxalate crystals. × 236.

38. A surface section of the lower epidermis; *g*, glandular hair. × 236.

39. A transverse section of a petiole; *bs*, bitter-principle sacs; *vb*, vascular bundle. × 11.6.

PLATE 5. TINOSPORA RETICULATA MIERS

FIG. 40. *a*, a habit sketch of a portion of the plant showing male inflorescence, × ½; *b*, a detached mature leaf with slightly cordate base, × ½; *c*, a single male flower, × 4½; *d*, a single wide open male flower, × 4½; *e*, a portion of an adult female stem bearing a cluster of fruits, × ½.

41. A diagrammatic drawing of a transverse section of an adult stem; *l*, lenticel; *scl*, sclerenchyma band. × 4½.

42. A group of cells taken from near the phellogen region and just outside of the cortical parenchyma; *co*, calcium oxalate crystals. × 450.

PLATE 6. TINOSPORA RETICULATA MIERS

FIG. 43. A portion of a transverse section of the cortical parenchyma; *e*, epidermis; *k*, flattened cork cells; *co*, calcium oxalate crystals; *sc*, stone cells; *g*, starch grain. × 156.

44. *a* and *b*, a group of cork cells isolated by maceration. × 224.

45. A group of stone cells isolated from the cortical parenchyma; *co*, calcium oxalate crystal. × 416.

46. A longitudinal section of a young bitter-principle sac, showing method of formation. × 416.

47. A transverse section of a bitter-principle sac. × 416.

48. A portion of an isolated bitter-principle sac. × 416.

49. A portion of a transverse section of the pericycle and cortex; *co*, calcium oxalate crystal; *scl*, sclerenchyma cells. × 336.

50. A portion of the longitudinal section cut through the same region as shown in fig. 49; *co*, calcium oxalate crystal; *scl*, sclerenchyma fibers. × 224.

51. A crystal fiber isolated by maceration from the outer part of the sclerenchyma band. × 224.

52. A group of parenchyma cells which became lignified, found between two sclerenchyma bands in a transverse section; *co*, calcium oxalate crystals; *sc*, stone cells. × 224.

53. A portion of a transverse section of a vascular bundle; *co*, calcium oxalate crystals; *mv*, metaxylem vessel with tyloses; *pr*, pith ray cells. × 156.

54. A group of cells isolated by maceration; *a*, sclerenchyma fibers; *b*, xylem parenchyma; *c*, a tracheid with spiral thickening; *d*, a vessel cell. × 104.

PLATE 7. TINOSPORA RETICULATA MIERS

FIG. 55. A portion of a transverse section of the pith; *sc*, parenchyma cells becoming lignified. × 112.

56. *a* to *c*, a group of isolated wood fibers. × 112.

57. An isolated vessel cell. × 112.

58. *a* to *d*, a group of isolated lignified parenchyma cells from the pith of a young stem. × 112.

FIG. 59. *a* to *c*, a group of stone cells from the pith of an adult stem. × 112.

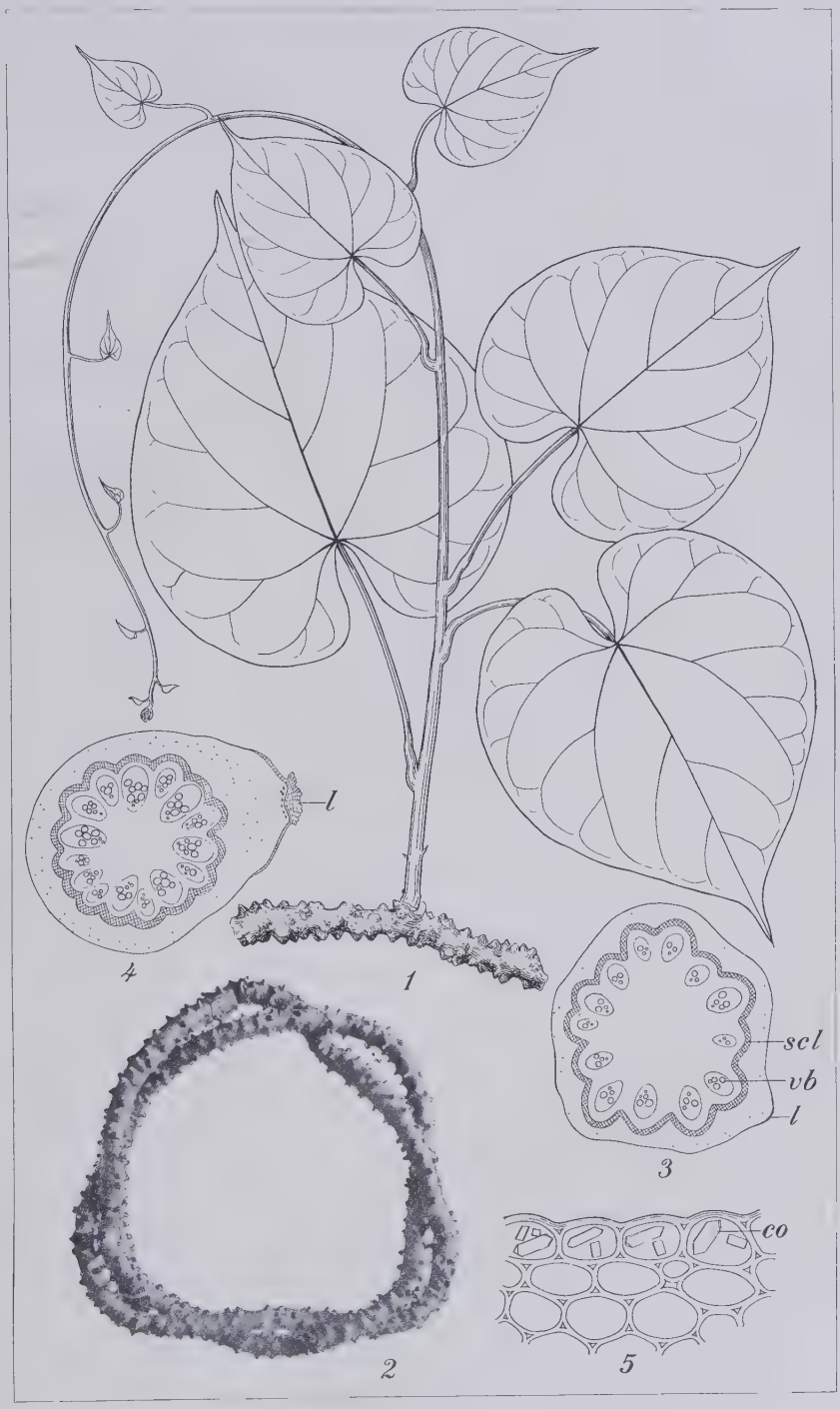
60. A transverse section cut through the pith of an adult stem; *sc*, stone cell. × 112.

61. A longitudinal section corresponding to fig. 56; *co*, calcium oxalate crystal; *sc*, stone cell. × 112.

62. A transverse section cut through the midrib; *col*, collenchyma; *scl*, sclerenchyma band; *as*, air space. × 362.

63. A surface section of the upper epidermis. × 221.

64. A surface section of the lower epidermis; *g*, glandular hair; *co*, calcium oxalate crystals in raphides. × 221.



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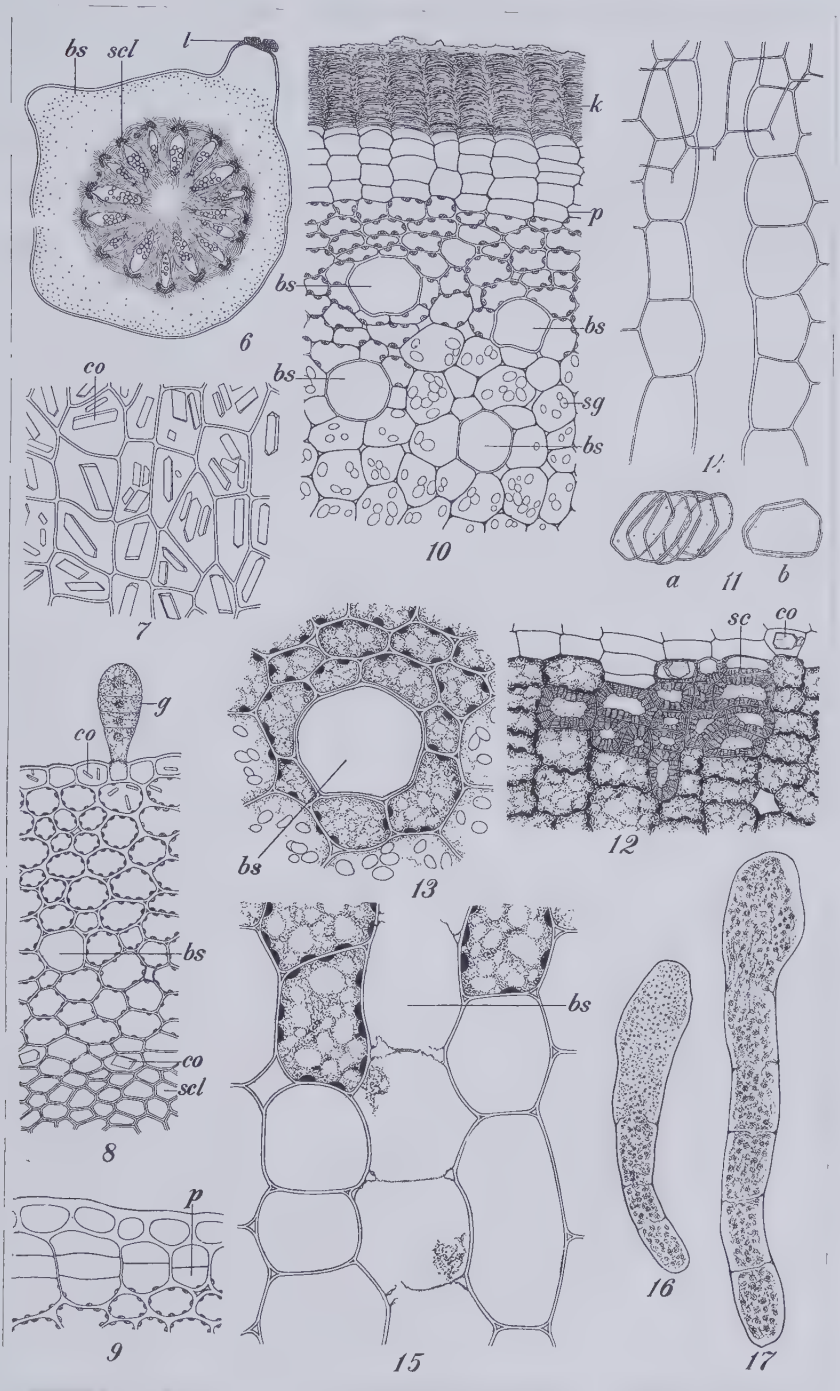
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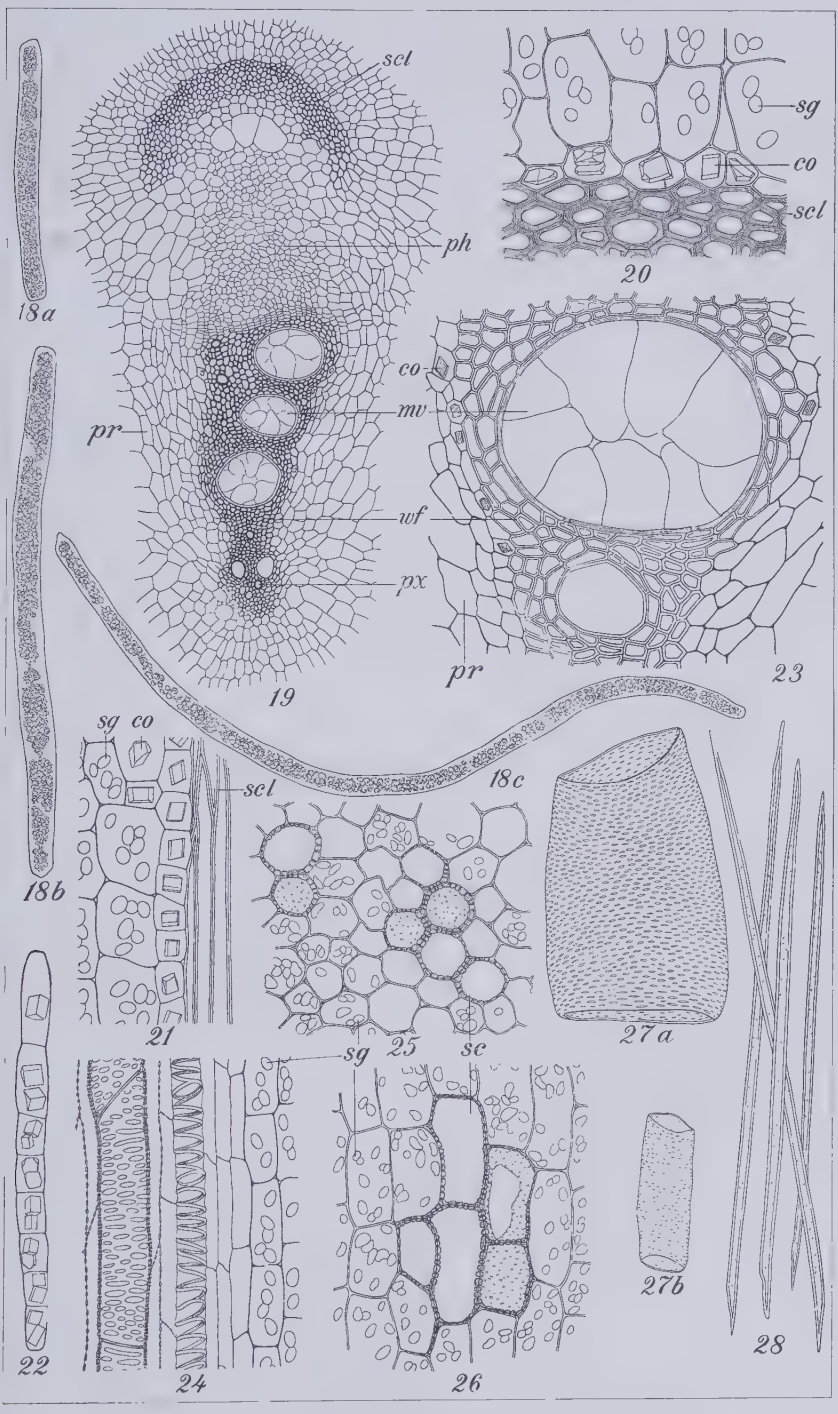
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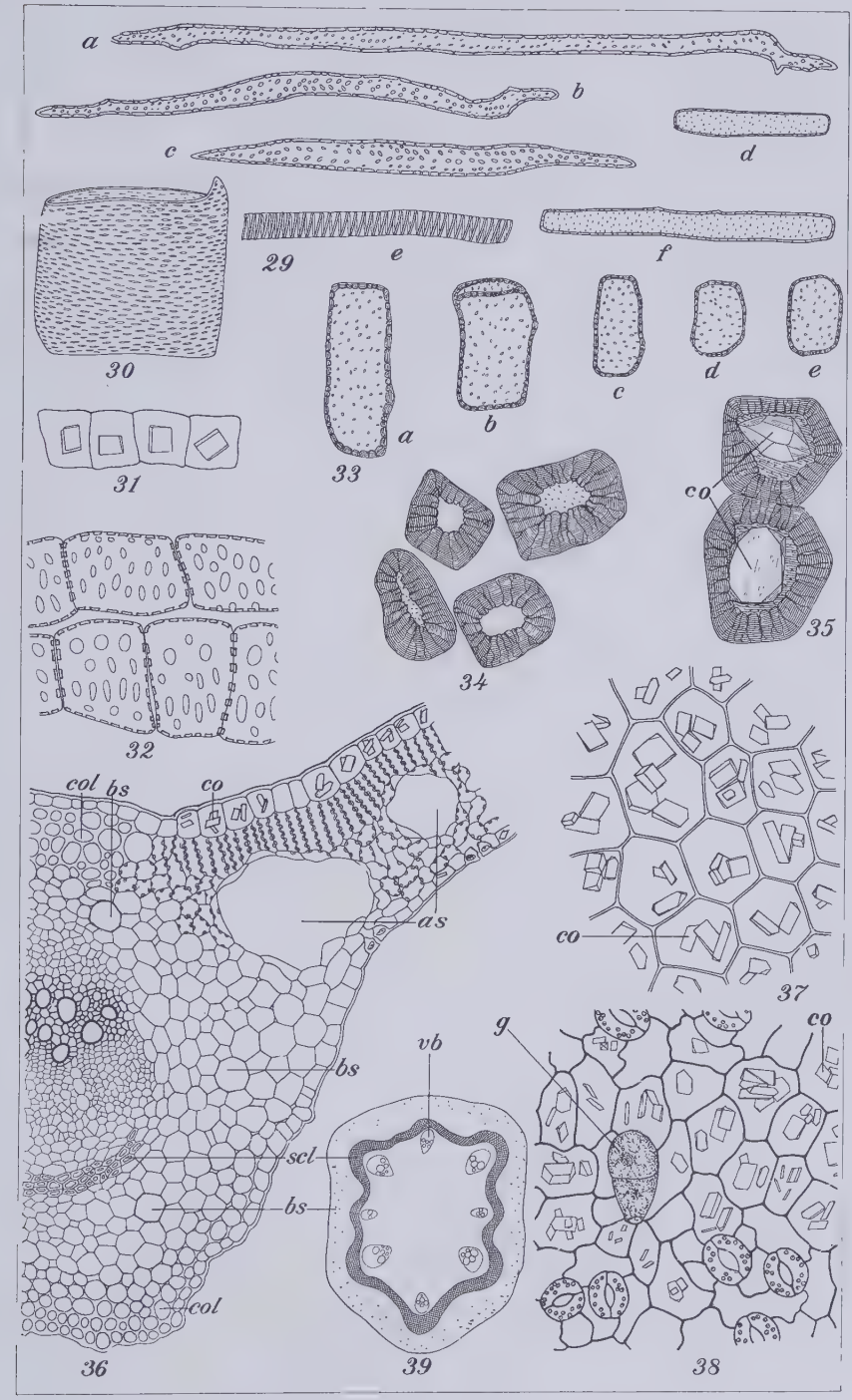
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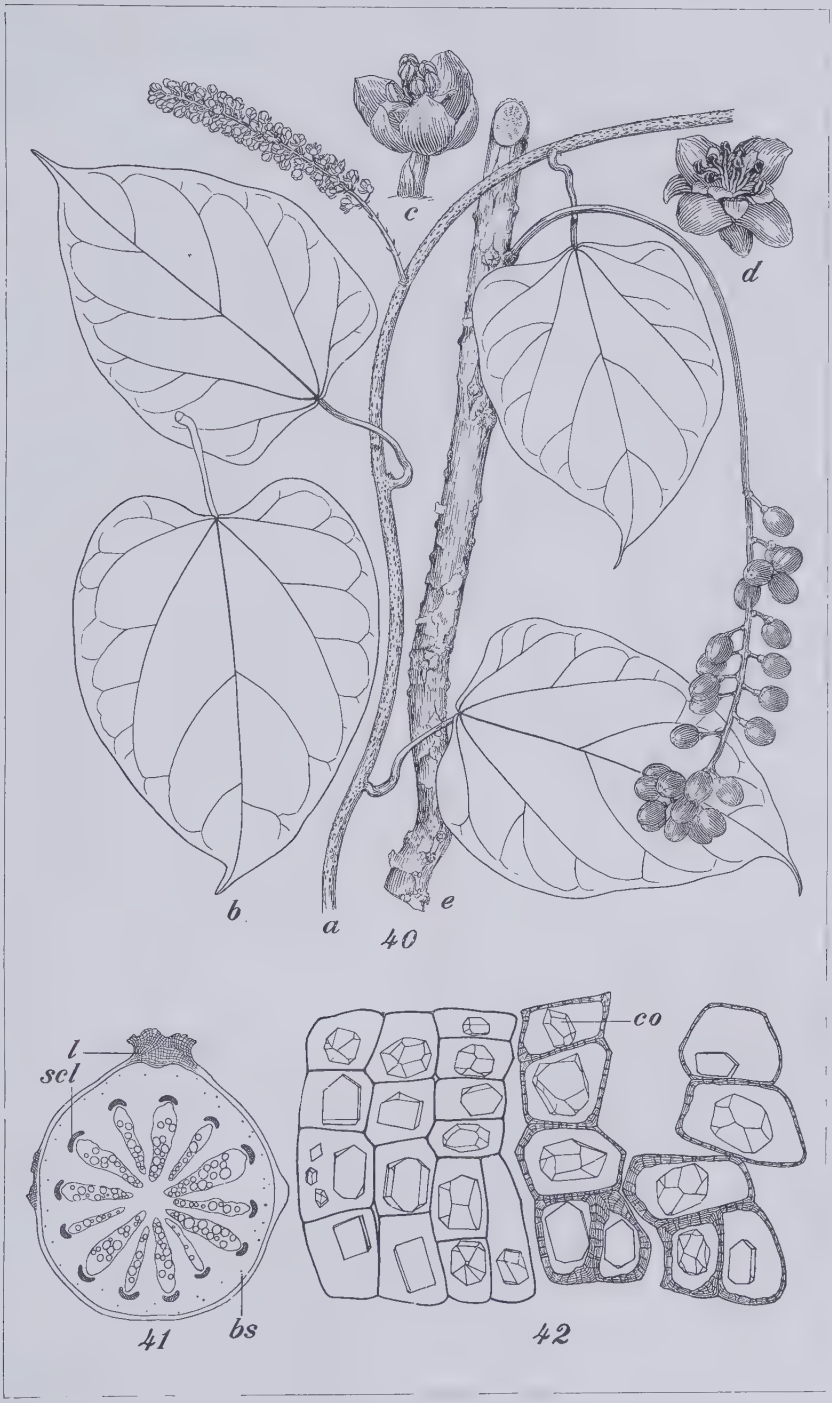

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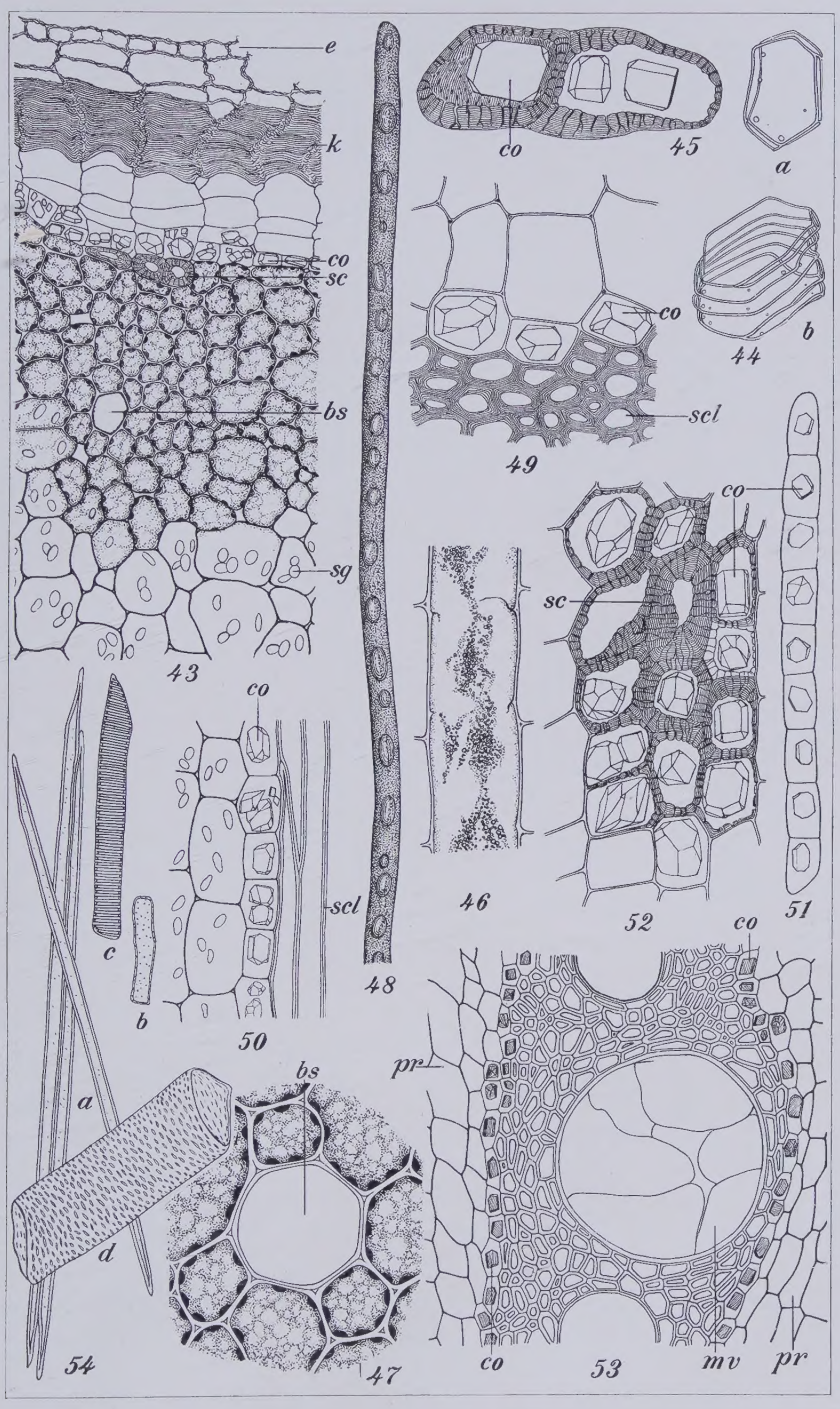
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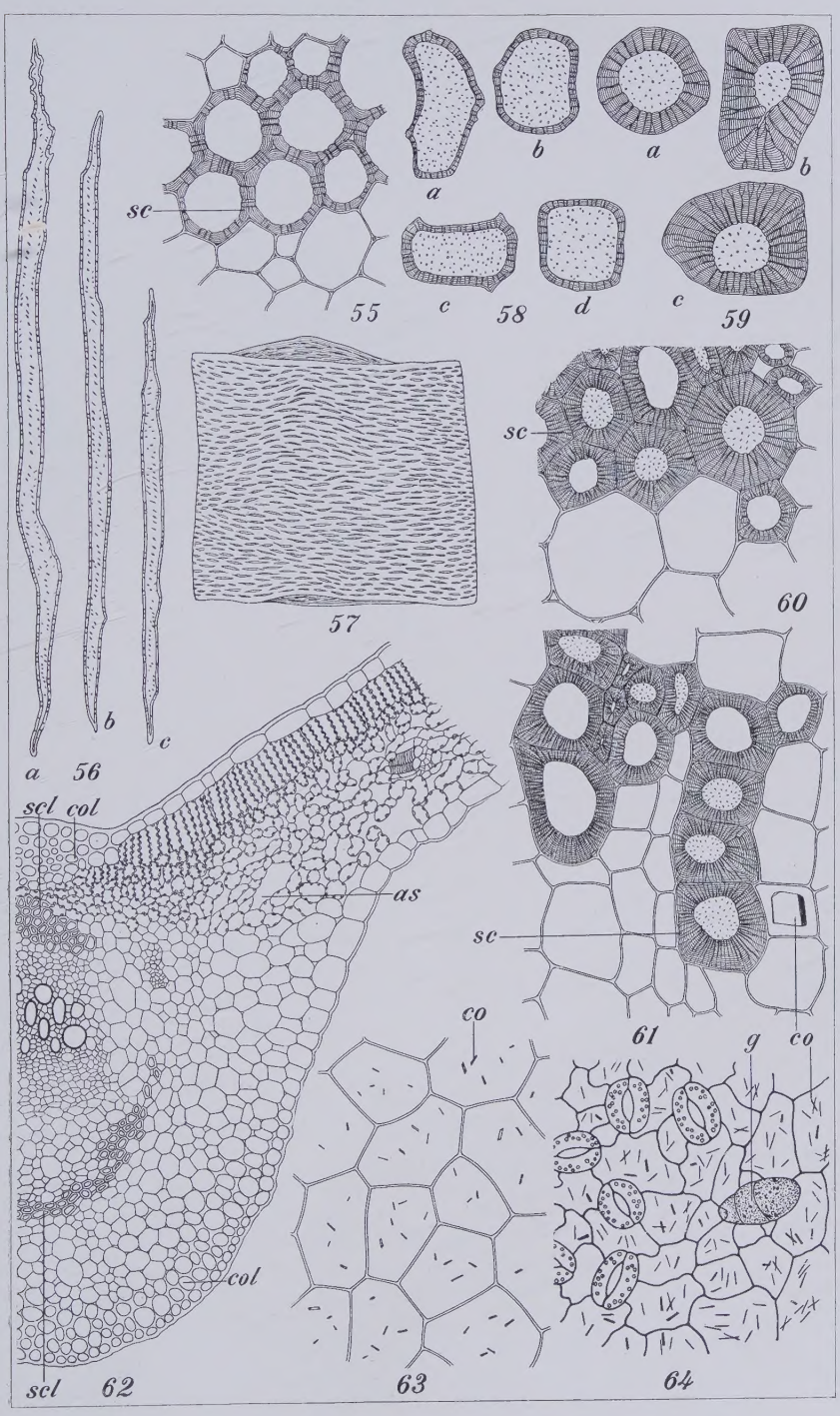
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PLATE 7.